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SCHOOL SCIENCE AND MATHEMATICS

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YOUR 1940 CONVENTION IN CLEVELAND

"Science, Mathematics, and Safety" keynotes the annual dinner meeting which will be held in the Ball Room of the Hollenden Hotel, Friday evening November 22, 1940. Sidney J. Williams, Vice-President, and former Engineering Director, of the National Safety Council will address the dinner guests on the subject indicated above. The annual dinner committee has also provided a first class musical program, and other numbers for your entertainment during the evening. This meeting promises more than "your money's worth" for every person attending the convention.

Other features of the coming convention in Cleveland have been arranged to offer professional stimulation to teachers whose special interests range from the primary grades to levels above the secondary school. "Man—Maker of Deserts," "Mathematics and the Consumer," "Park Areas as Teaching Assets in Biology," "Rescuing Physics from the Textbooks," "Some Observations on the Physical Development of Adolescent Children," "Music Makers in Science Time," "The Mathematical Interpretation of History," "The Motor Car's Debt to Science," and "Experimental Science for the Citizen," are samples of the several dozen discussion topics for this convention which has "Science and the Citizen" for its theme. A complete copy of the general and sectional programs is printed on pages 795–800 of this issue.

The Hollenden is the convention hotel. It is located in downtown Cleveland, at the corner of Superior Avenue and East Sixth Street. This location is two blocks from the railroad terminal, and is within a five minutes walk from the downtown

theater and shopping district. Ample parking facilities, both indoor and outdoor, are available within a block of the hotel.

The ten local committees, and other mathematics and science teachers of Northern Ohio take this opportunity to welcome you to the convention.

NATHAN A. NEAL, *President*

MATHEMATICS PREPARES FOR NATIONAL DEFENSE

At the joint meeting of the American Mathematical Society and the Mathematical Association of America held at Dartmouth College, Hanover, New Hampshire, on September 9-12, 1940, the following resolutions were adopted, upon the recommendation of the War Preparedness Committee, Professor Marston Morse of the Institute for Advanced Study, Chairman:

1. That all competent students in the secondary schools take the maximum amount of mathematics available in their institutions. In the case of many schools additions to the present curriculum will be necessary in order to furnish an adequate background for the military needs of the country.
2. That the colleges and universities at once make such revisions of their undergraduate courses in mathematics and add such courses to the curriculum as are necessary to prepare students in the elements of mechanics, probability, surveying, navigation and other essentials of military science.
3. That the graduate schools extend their courses in applied mathematics, such as dynamics, hydrodynamics, elasticity, aeronautics, ballistics, statistics, etc., and that advanced students be urged to become highly qualified in one or more fields of applied mathematics.

This is the first step in the fulfillment by this committee of its dual mission of education and research.

Subcommittees were constituted with chairmen as follows:
Research—Professor Dunham Jackson, University of Minnesota;
Preparation for Research—Professor M. H. Stone, Harvard University;
Education for Service—Professor W. L. Hart, University of Minnesota.

To aid in research, chief consultants were named in the following fields:
Ballistics—Professor John von Neumann, Institute for Advanced Study;
Aeronautics—Professor Harry Bateman, California Institute of Technology;
Mechanical and Electrical Aids to Computation—Professor Norbert Wiener, Massachusetts Institute of Technology;
Industry—Dr. T. C. Fry, Bell Telephone Laboratories;
Cryptanalysis—Professor H. T. Engstrom, Yale University;
Probability and Statistics—Professor S. S. Wilks, Princeton University.

ACID PROOF RUBBER

Tubing made from synthetic rubber has been found to withstand the action of acids and other corrosive chemicals far better than if made from the natural product. An experimental length supplied three years ago to a large copper refinery to carry a 16 per cent sulfuric acid solution is still in good condition, though rubber tubing had previously failed after six months.

ARE BEGINNING TEACHERS OF HIGH SCHOOL MATHEMATICS ADEQUATELY TRAINED?

W. G. GINGERY
George Washington High School, Indianapolis, Indiana

The topic assigned for this paper is manifestly a rhetorical question. The answer is that beginning teachers of high school mathematics are not adequately trained. Such a statement however is without profit unless one can tell something of the respect in which they might be better trained.

It has been only a few years since we began teaching teachers to teach. When I joined the ranks of the profession, the techniques of teaching were supposed to be innate. If one were able to teach he was a born teacher. In those days the mathematics was better taught than most any other subject. There are two reasons for this situation. First the mathematics is an ancient subject and the centuries have refined and organized it into an orderly discipline with simply graduated progress from the less to the more difficult. Such a subject lends itself more readily to the efforts of the untrained teacher. In the second place, in those days mathematics was considered the most important ingredient of education and a pupil who could not readily master it was soon eliminated from the school. In that case only those who could easily learn the subject remained to be taught. No other subject enjoyed such distinction as did the mathematics for limiting the school enrollment.

Since the training of teachers began the ease with which mathematics was traditionally taught has been a disadvantage to it. For years it was assumed that anyone could teach algebra or geometry and so the department was largely parcelled out to teachers of other subjects who had an extra period or two. In the meantime other subjects, notably English and social science, have taken the key positions in the curriculum and the student body is no longer limited to those who can learn mathematics easily.

While these changes in the pedagogical situation have been taking place the world in which the student is to live has been growing rapidly more complex and more inclusive and the major part of this growth has been quantitative. It takes many more as well as more complex quantitative concepts to live successfully now than it did a half century ago. All this has increased

the burden on the already abbreviated courses in mathematics and made it still less possible for the students to master it. The public now compares the pupil's ability to manage his present complex quantitative situation with the pupil of forty or fifty years ago in a much simpler situation and blames the present mathematics teacher for the unfavorable impression her pupil makes.

Actually the statement of the topic assigned for this paper affords the high school teacher an opportunity to pay off an old score. I presume that the most cogent reason that may be assigned for young mathematics teachers not being well prepared is the fact that much, possibly most college teaching of mathematics is deadly dull and insignificant. The other day while interviewing a student still in college who will be a candidate for a mathematics position I picked up a program of the Indiana Section of the American Mathematical Society. Much of that program is devoted to Topology. I asked the candidate to define Topology. Like myself he had never heard of it before. But he said "I will ask my professor. He will know and he will tell me. But after he tells me I will not know, for that is the way with everything he tells us. He makes nothing clear or interesting."

In Indiana, I believe the Calculus is now required of all candidates for mathematics license. It is certainly the most important course in the group known as higher mathematics and it is the most powerful of all the tools in the kit of the mathematician. The most significant concept of all the calculus is the derivative. It is therefore a pretty important concept. Probably the invention of the derivative should rank with the discovery of the law of gravitation or the discovery of radium in importance as a contribution toward man's understanding of and control of his environment. I frequently ask young candidates for teaching positions to define the derivative. Very few of them can. To most of them, as a concept it means nothing, yet they have ground through hundreds of problems using it, for hopelessly dull answers that likewise meant nothing to them beyond being right or wrong.

It is not the fault of the mathematics. It is significant enough. Much of it can be shown to touch upon the most real situations in which the student lives. It furnishes foundation material for all quantitative considerations which include the whole economic and scientific structure of modern civilization. It illus-

trates and supplies exercises in the fundamental concepts of logic on which rest language and communication. The fault lies in the fact that it is too often presented as a dead, dry, abstract subject with no significance to the average individual.

There are three important items in the training of a mathematics teacher. The first is complete mastery of that part of the subject field to be taught. This includes an analysis of the subject matter into small simple steps graduated as to difficulty and involving only one new concept at a time. Text book writers have done this well, but it is important that the teacher know about it and be on the alert for improvements. In this respect the mathematics is best of all subjects. It can be mastered by taking just one step at a time and these steps can all be made simple. Confusion occurs when a new concept is presented before the previous ones are fixed or when a complex of several concepts is offered as one increment or when a pupil or class has missed a concept on which later ones depend. A teacher should be taught to first find out, by comprehensive review or tests, what progress the pupil has already made, then to analyze the subject matter into increments and begin to instruct where the pupil's competence leaves off.

The second important item is a love and enthusiasm for the subject. This should be furnished by the college professor as well as by the high school teacher, and it *can* be done by a teacher who senses the real significance of its various branches. For centuries it has been an inspiration to those who understood and followed it, and it is not too much to say that only a person who has caught the real thrill of power that only the mathematics can give is qualified to teach it. Otherwise one's teaching is routine, wooden and meaningless like a succession of calisthenics for only the docile and stolid to follow while the pupil with creative energy goes wool gathering.

One would not expect to become a good athletic coach if he avoided all athletic functions except the routine of coaching his team. Neither does one who does not read the literature of the language he teaches become a very inspiring language teacher. Similarly it should not be expecting too much of the mathematics teacher that his interest in the subject should extend beyond the part of the subject he teaches. He should have an active interest in extending his grasp of the subject not because it is his duty but because of the real thrill that it furnishes.

The other day a young woman (I have even forgotten her name) applied for a position teaching high school mathematics. I questioned her about the calculus, the differential equations and the theory of probability in investments and annuities. She finally replied, "Well, I don't see that it makes much difference if you are just going to teach algebra and geometry whether you have had any of that stuff or not." And I suspect it wouldn't make much difference to her pupils either. She might become a good drill master but her students would forever be deprived of the thrill of adventure.

The third item is the establishment of a personal storehouse of illustrative material and application. This storehouse must be filled by the teacher himself through excursions he may take into the real experiences of life. He must have shared many of the experiences of his pupils but he must also have become familiar with a great variety of the quantitative relationships of our complex civilization. This background will give reality to his teaching.

As previously remarked the relative importance of the position of mathematics in secondary and higher education has been considerably reduced in the past few years. In the secondary field this reduction has been chiefly in favor of the English and social studies. And this change in emphasis has taken place in the presence of the fact that our culture and our industrial and economic systems are becoming increasingly more quantitative and more dependent upon the mathematics.

The change has taken place, not because it is inherent in the set up of our civilization but because the mathematics has been in the hands of people who neither understood nor appreciated its significance and could not transmit to their classes what they did not have.

The readers of this magazine are probably representative of the best in the country in secondary mathematics teaching. You read this and other teachers' magazines fairly regularly. Yet those who, because of your own interest in it, regularly read strictly mathematical writings of any grade constitute an almost negligible per cent. Number theory, mathematical analysis and modern geometry offer opportunities for such reading without entering the more highly specialized fields. The teacher who is prompted to put forth a little effort along these lines will find the exertion stimulating.

Until secondary school mathematics is in the hands of teach-

ers who have real mathematics scholarship enough to be able to continue to read the subject independently and who have been inspired by their professors with a love and enthusiasm for the subject that will keep them going on with it even after completing all degree and license requirements, the mathematics will not come into its own and our cultural and economic development as a people will continue to be retarded.

TRISECTION OF AN ARBITRARY ANGLE

V. H. PAQUET, Portland, Oregon

Let OPA be the constructed half loop of a right strophoid of which O is the double point.

Erect AB perpendicular to OA at A.

Lay of the given angle BAC.

Bisect angle CAO and draw the bisector AD.

Construct an arc of a rectangular hyperbola passing through A in the following manner:

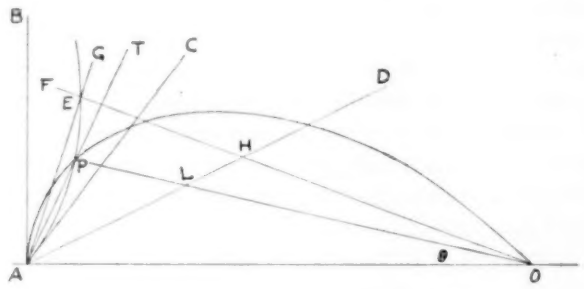
Let OF be any line from O passing through the strophoid, and let H be its point of intersection with AD.

Make angle HAG = angle AHF.

The point of intersection of OF and AG is a point on the hyperbola.

Through the point P, the intersection of the arc of the hyperbola with the strophoid, draw AT.

Angle CAT is $\frac{1}{3}$ of the given angle BAC and is equal to θ.



Proof

Draw OP, and let L be its point of intersection with AD.

By known properties of the strophoid, angle $OAP = 90° - 2\theta$.

$\therefore$ angle $BAT = 2\theta$.

By construction, P being a point on the hyperbola, angle LAP = angle ALP = angle $OAL + \theta$.

But by construction:

angle OAL = angle LAC.

$\therefore$ angle LAP − angle $LAC = \theta$ = angle CAT and since angle $BAT = 2\theta$, the given angle $BAC = 3\theta$.

Therefore angle CAT as constructed = $\frac{1}{3}$ angle BAC.

THE SCIENCES NEED THE SOCIAL STUDIES*

PHILIP G. JOHNSON
Cornell University, Ithaca, New York

This joint meeting of the Social Studies and Science teachers is a remarkable condition of affairs. It makes many of us feel somewhat like Calvin Coolidge must have felt at one time when he was President. It is said that he looked out of his window and saw Senator Borah riding on a horse. The President turned to his secretary and remarked, "There is a remarkable sight." The secretary looked and seeing nothing unusual asked, "Why?" The President responded, "The horse and the Senator are both going in the same direction." For the same general reason this meeting seems to be remarkable.

As science teachers, we have felt and often recognized some traditional debts; our debt to our subject and its traditions, our debt to the laboratory and its traditions, and our debt to the methods of learning through which we came to possess a portion, of the science heritage. The social studies teachers, I suppose, have felt and recognized somewhat similar debts. For all too long a time, we have been paying on these traditional debts without realizing that the payments were based on an unwise system of accounting. It seems that we have gone along rather blindly paying our traditional debts. Now we are being forced to question the results. For what purposes are the payments being used? Are the payments contributing anything of value, or are we paying for the traditional "dead horse"?

The lack of vocational opportunities and some other factors have caused a large number of boys and girls to remain in school who would normally have found jobs. This has caused us to question the type of payments we have been making. Furthermore, the concern of education for democracy in the face of difficulties at home and abroad, has further challenged our serious thought as to the motives which have apparently determined the nature and content of our courses. Now we are being pushed by our debt to youth as compared to our traditional debts. Our situation is somewhat like the poor colored woman who was being approached for a pledge to the local church. She complained that she already owed almost everybody something. The

* A paper presented at a joint district conference of the New York State Science Teachers Association and the New York State Council for the Social Studies held at Glens Falls, N. Y., on May 4, 1940.

collector tried to challenge her by asking if she felt no debt to the Lord. She replied that she did, but the Lord wasn't pushing her for payments. It isn't so much a matter of, does science education pay, or does social studies education pay. The question is, is education really worth what it costs. We need to cast aside our traditional and circumscribed goals and devote our attention cooperatively to the purposes of education. That we have a common debt to discharge has been clearly revealed by numerous commissions and committees during recent years.

Teachers of different subjects and at different levels often express their goals in different terms. However, when these are analyzed we usually find that they are but variants of the three basic outcomes; knowledges, skills and attitudes. The science teachers may be thinking of scientific facts, hypotheses, theories, principles, and laws when they use the term "knowledge." They may immediately think of "scientific thinking" when the word "skills" is mentioned, and "attitudes" immediately suggests what they choose to call "scientific attitudes." Intelligent behavior demands knowledge, but it also demands some appropriate skills and attitudes. It is not an accident that the scientist is often satirized as a person with bone-rimmed glasses and a collecting net, rushing about catching an insect, completely oblivious to the amusement of the by-standers. The scientist may say that he is searching for the truth but the bystanders are amused. Certain it is, that scientists often overlook social attitudes while they are busy trying to develop scientific attitudes. Whatever may be our own shortcomings, the boys and girls will grow into men and women who will live in a social as well as a scientific world. It is our job to help them to live in such a world. with the hope that what we help them accomplish in school, may influence them when they leave school. This being axiomatic, let us consider how we can pay our debts in more significant manners.

In order to work cooperatively it is necessary for us to become possessed by certain ideas. Let me state them and then give some examples:

1. Teachers need to be motivated by such modern objectives as social competency, broad appreciations, personal health, critical thinking, and functional understandings. We need to think less about the minimum essentials of our subjects and more about what we in our varied fields can contribute to the life of the pupils. We need to give greater regard to the needs and in-

terests of our pupils and less devotion to the scope of our subjects. As science teachers, we may not agree with Dr. Caswell when he writes: "The unquestioned use of principles, laws, and generalizations as primary basis for organization of curricular materials in science makes difficult, if not impossible, the development of a curriculum in which science materials along with other materials from other subjects are related to significant functional aspects of life." Our failure to agree does not make this statement either true or false. Perhaps we have been too sure of our method of doing a professional task. Perhaps we have, through our own sureness, inhibited a development which would mean much to our pupils. Surely we should be scientific enough to be willing to consider another point of view with the further implication that we may desire to subject the idea to a controlled trial. We need to become possessed by the idea that all of us, regardless of the field, have a contribution to make to youth, and that the basic purposes are to be shared by all of us, if we are to do our job intelligently.

We need to recognize further that the broad objectives of education cannot be attained through any one subject in any single year. We need to join with other teachers in the cooperative planning of the offerings of the school. This may result in broad field courses sometimes called core-offerings, or it may result in separate courses which have been planned to integrate with other offerings. We need to plan greater continuity from grade to grade so that there will be prolonged building toward fundamental goals. In this connection we should not forget the great truth stated by John Dewey, "It is generally now admitted that the most fundamental attitudes are formed in childhood, many of them in the early years." Science teachers, if they are interested in making science training really count, must have a vital interest in science for the elementary schools. Here is another need for cooperation, since secondary science teachers may know the science but they often do not know children, while the elementary teachers know children but often are relatively unfamiliar with science.

One hindering condition which seems to be a rather general characteristic of people is that *they are down on what they are not up on*. Time does not permit me to give you the "low-down" on cooperatively planned courses but among the better examples we find the work at Hopeville, Alabama and at Tulsa, Oklahoma. At Hopeville, the stress has been placed on doing something for

the community that is truly useful. Useful projects grew out of a community survey to note resources and opportunities. It was discovered, among other things, that many people suffered from a lack of green vegetables during the winter although there was an abundance during the summer. Here was a real and vital problem. How could the winter deficiency be met? The entire school undertook the study of the problem. Methods were uncovered, costs determined, and plans compared. The final result was the establishment of food lockers as a community service. Another vital problem related to soil erosion control. Many teachers took part in the study and in the planning and publicity necessary to see the project through. The pupils found satisfaction in bringing about some genuine community services. This sensing of community needs and doing something about it represents qualities greatly to be desired in any individual.

In Tulsa, Oklahoma, there has been worked out a core program for a six-year period. No single subject or any single year is expected to bring about one or more of the major goals. The plan is based on the idea that the entire school through its teachers needs to devote six years of continuous attention to the needs of the pupils. Details of these examples can be obtained by correspondence.

Another important idea to be considered by all teachers is that young people do not express themselves or learn through a single media. Handiwork, crafts, music, art, drama, and the like, are to be considered as worthy, perhaps more worthy, than the more common write-ups, answers to questions, solving of problems, and preparation of reports. I shall never forget the result from motivating and encouraging a ninth grade general science student to express himself in terms of drama. We were studying about microorganisms and, as I regularly do, I proposed that someone might want to present some truths related to this topic in the form of drama. One boy, interested in dramatics, noted a brief preview of the movie, "The Life of Pasteur," in a movie magazine. He remarked that he would like to write a play based on the life of this man. I helped him with sources and he wrote the whole dialogue; four acts and seventeen scenes. I encouraged him to try to produce it and helped him by preparing copies of his script. He selected the cast, directed their practice, and it was finally presented in the classroom with another class invited in. Later a home-room wanted to sponsor the production as an auditorium presentation. Again he planned the scenery,

directed the practice, and the play was presented. About two weeks later the photoplay came to the local theater. There was great interest and Ed went too. He came to me a day or two later and said, "We did't agree in all parts of the story. I think I was right, but I wonder." I contend that this optional task did much for Ed and much for the entire community. Just how much we can never know, but more than just another paper or report.

Another example is the following which was prepared and handed in at the close of a study of the topic "air" in General Science:

AIR

Gift of all the world so bright
Needed by us day and night
Science shows us marvels rare
Of this substance called the air.

Oxygen and Nitrogen
Form a mix without a peer
Their blending in proportions right
Give us our atmosphere.

Colorless and odorless
Around us everywhere
Life in this world could not exist
Without sustaining air.

—Olivia Bussell, 9th grade

A fourth consideration is the idea that fundamental and exceedingly worthy outcomes are a result of pupils sharing in the planning as well as in the working out of plans. This idea means that pupils should sit in the planning groups and participate in the broad activities of the school. Curriculum planning and evaluation is not to be excepted. This idea of pupil planning may cause many teachers to withdraw into their traditional shells, because it may seem that the proposal means that pupils rather than teachers should select the content, plan the study, and measure the results. Some school people see in this idea a completely child-centered school. This may have been the idea in some schools in the orange-crate stage of progressive education but the idea now is cooperative planning. Obviously, the teacher should do a great deal of planning, much of which may prevail finally, but pupils should also share in this important activity. All pupils cannot sit on all committees, but all pupils can share in some part of the planning, even if it is nothing more than arranging for a field trip, helping to form groups for group study, or planning for an interview with the school doctor.

A fifth and closing consideration should be the idea that there is no one way to solve the problem. Each curriculum approach now current is but an hypothesis to be tested. The eagerness of teachers at all levels and in all fields to cooperatively plan their parts in the educational program of the school, and then to realistically measure the results constitutes the most hopeful aspect of the modern trends.

You may think that the implications of these ideas are impossible of application in your school and in your community. Let us therefore consider some other plans which may represent approaches toward the same general goals.

1. You may be teaching two subjects in successive periods. You may even have the same pupils in both classes. In that case you can plan for a double period in a fused subject. English and Social Studies, English and Science, Science and Shop, Science and Mathematics, are examples of such possibilities which have been tried with evidences of success.

2. You may desire to plan a project with one or more other teachers. This project may involve a few weeks' cooperative planning and working. Topics such as the following reveal many possibilities for cooperative work between science and social studies teachers: The History of Science, The History of Inventions, Communication Yesterday and Today, Transportation Yesterday and Today, Science and Modern Warfare, Technological Unemployment, Public Utilities, Housing, Soil Conservation, Game Laws, Advertising, Crop Control, Sanitary Codes, Health Regulations, Photography in American History, Cooperatives, Health Insurance, Hospitalization, and a host of other topics.

3. You may desire to introduce individualized instruction or group study within your own classes. In my general science classes as well as in all our chemistry classes we are now engaged in group work. The planning of groups, discussions of the importance of cooperation between and within groups using such examples as the Community Chest, the G.L.F., or the Rockefeller Foundation, 1939 review, especially the section entitled "Divided We Fall," will result in some development of some social attitudes. Planning for group work provides a situation where discussion followed by actual practice is possible. The sharing in working out plans, and in making results available to other groups, develops a cooperative spirit akin to that which prevails between scientists, regardless of country, race or religion.

4. It is possible to plan one or more sections of a core-curriculum type of offering. Such a course has been planned for the Ithaca Senior High School and will be offered as soon as conditions make it possible. Many meetings were spent in planning the general organization. Much more time will be required to visit the homes of the pupils and in planning the details with the pupils. In our plan the Home Arts, Social Science, English, and Science will form a unified core with all the other subject teachers cooperating as necessary. The work will be done in three blocked periods in a separate home-room planned for the experiment. Later we may be able to relate more specific problems and plans.

5. It may be possible to plan and teach some type of consumer science in which the needs of pupils are more clearly recognized than in the more traditional courses.

Many other possibilities relating to the general goals may be possible such as planning excursions, field trips, health and safety campaigns, clean-up-campaigns, and the like. The way to begin is to start.

Let us summarize why the sciences need the social studies.

1. In order to bring socially desirable practices into the science classroom.
   a. Socialized recitations.
   b. Surveys of community services and needs.
   c. Social significance of scientific discoveries.
2. In order to give historical perspective to the science of the present.
   a. The development of transportation.
   b. The development of communication.
   c. The development of homes and home conveniences.
   d. The development of manufacturing.
3. In order to be mutually helpful.
   a. In developing a core-curriculum type of offering.
   b. In making the science emphases in the social studies more accurate.
   c. In order to secure an agreeable timing for the science of social studies and the same science emphasis in science classes.
   d. In order to avoid mere verbalization about science in the social studies.
4. In order to help science teachers to redefine their goals along social lines and to recognize such goals in content and in instruction.

5. In order to make a more favorable place for both science and social studies in a program in which all subjects compete for a chance.

In addition to the eagerness of teachers, there are certain implications for the administration, if the work is to succeed. Some of these ideas appear to be about as follows:

1. There must be a willingness to evaluate results and a teacher's success in terms other than the accumulated information of pupils. A poor test for growth in critical-mindedness may be more valuable than a good test for information.

2. There should be facilities and equipment for real individual experimentation on many non-traditional laboratory projects. Such experiments may be testing the values of various water softeners or determining the amount of alkali in various brands of soap.

3. There should be an abundance of texts, magazines and pamphlets, as references, readily available to the students. These reports may well be from the Bureau of Standards and consumer reports, as well as from vocational data.

4. There should be transportation facilities for bringing pupils into real situations for first-hand study. This may require buses as well as liability insurance for teachers.

5. There should be a recognition that programming of subjects is a part of a system rather than an absolute necessity. Thus there should be a willingness to adapt the program to make possible learning experiences which require more than one period. Field trips, community surveys and the like, are examples.

6. There should be a willingness to allow some teachers a decreased teaching load and other facilities, in order to give time and energy for planning and directing pupils in tests of what appear to be helpful learning hypotheses.

7. There should be provisions for promoting and graduating pupils who follow the new plan.

8. The new plan should be regarded as desirable and cultural as the more traditional plan.

9. There should be a willingness, indeed an eagerness, to give much time and thought to sharing in the planning and otherwise helping with the development of the new offerings.

10. There should be a willingness to approve the use of some school funds for enriching the social life of the pupils and for providing materials needed in cooperative undertakings.

REFRACTION AND MIRRORS

HOLLIS D. HATCH

English High School, Boston, Massachusetts

How much better are metal mirrors than glass ones in the Plane Mirror experiment? In the March 1939 issue of SCHOOL SCIENCE AND MATHEMATICS Dr. Glen W. Warner urged the adoption of metal mirrors because of the refraction by the glass of the silvered glass ones. I will show just how much this error amounts to and what to do about it.

In the diagram a ray of light from the object O meets the front surface of the mirror at angle a, is refracted at angle b, reflected by the silver at Q, again refracted and emerges into the air. I assume uniform thickness (t) for the glass. The usual diagrammatic method of locating the image is to draw a similar adjacent ray from O and extend the emergent rays back to their apparent meeting point. Instead in this case we may locate I by the intersection of one emerging ray extended backwards and the extension of the perpendicular from O to the mirror. It is obvious from the diagram that while reflection actually takes place at Q, the incident and emergent rays appear to have been reflected at P.

If you do as I do and have the boys measure object and image distances from the silver surface, they obviously should not get the distances equal to each other. The point P is nearer the observer by the distance x; thus the student who locates his image correctly will have an object distance greater than the image distance by $2x$; and the student who gets his distances "right" is wrong.

(A) How large is this error? (B) How does the incident angle affect it? (C) How can the error be minimized or avoided?

From the diagram:

$$(1) \qquad \tan b = \frac{y}{t} \qquad (2) \quad \cot (90-a) = \tan a = \frac{y}{t-x}.$$

Equate the values of y from these equations and

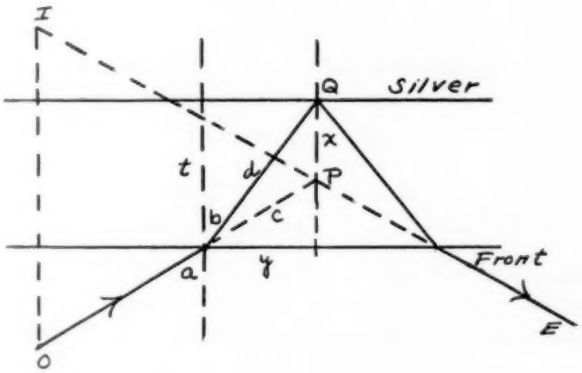
$$(3) \qquad (t-x) \tan a = t(\tan b)$$

$$(4) \qquad t-x = \frac{t(\tan b)}{\tan a}$$

(5) $$x=t-\frac{t(\tan b)}{\tan a}$$

(6) $$x=t\left(1-\frac{\tan b}{\tan a}\right).$$

What are the limits of $1-\frac{\tan b}{\tan a}$?



The value for a tangent by infinite series is:

$$\tan a=a+\frac{a^3}{3}+\frac{2a^5}{15}+\frac{3a^7}{75}+\cdots.$$

When the angle is small raising it to the third, fifth, etc., power gives a still smaller quantity; thus we can say that as a becomes very small tan a practically equals a. From the definition of index of refraction we have

$$\frac{\sin a}{\sin b}=n.$$

A similar series for the sine also shows that the sine approaches a when a becomes very small. For small angles therefore

$$\frac{a}{b}=n \qquad \text{or} \qquad a=bn.$$

Combining the above, the limit for

$$1-\frac{\tan b}{\tan a}$$

as both a and b become small is:

$$1-\frac{b}{a}=1-\frac{b}{bn}=1-\frac{1}{n}.$$

If glass with $n=1.52$ is used we have

$$x=t\left(1-\frac{1}{1.52}\right)$$

$$x=.34t.$$

For larger incident angles the maximum for a is 90° whose tangent is infinitely large; b is never as large as a, so its tangent has a finite value. Thus the limiting value of

$$1-\frac{\tan b}{\tan a}$$

as a approaches 90° is one minus an infinitely small fraction, i.e., only one, and the limiting value of x is t.

The above shows that there is always an error and P is never at Q. It is nearest (about one-third the glass thickness away) when the incident ray angle is small; P is further from Q as the angle increases up to a maximum error of the whole thickness of the glass for large angles.

An interesting question is: "When is P half way between front and back of the glass?." From the equations

(7) $$c^2=\frac{t^2}{4}+y^2$$ (8) $$d^2=y^2+t^2$$

and

(9) $$n=\frac{\sin a}{\sin b}=\frac{y/c}{y/d}$$

we can get

(10) $$n^2=\frac{4(y^2+t^2)}{4y^2+t^2}$$ (11) $$n^2=\frac{4+4(\tan b)^2}{1+4(\tan b)^2}$$

(12) $$(\tan b)^2=\frac{4-n^2}{4n^2-1}.$$

Note that (12) shows that this particular angle is a function of the index of refraction and independent of the thickness. If $n=1.52$ this gives $b=29.8°$ and $a=49°$.

We are now ready to answer the question we asked ourselves. If we assume reflection is at the silver surface (A) How large is the error? It is from two-thirds to twice the thickness of the glass of the mirror. (B) How does the incident angle affect the error? The error is greatest when the angle is largest. (C) How can the error be minimized? Use a thin glass mirror (which breaks easily) and stand the mirror on a line *half way* between front and back surfaces. This reduces the maximum error by a half and for incident angles near 49°—a very common occurrence—the error becomes negligible. Even placing the front of the mirror on the line usually gives less error than the customary way of putting the "reflecting surface" over the line.

I think this analysis explains why Mr. Warner prefers metal mirrors. I had several made up and found my students got distinctly better results with them. But if you have some glass mirrors you feel you should use, the above will help you to get the best results with them.

A NEW DIRECTOR FOR THE MARYLAND ACADEMY OF SCIENCES

Dr. J. Wallace Page, Jr. has been appointed Director of the Maryland Academy of Sciences. Dr. Page comes to us from Syracuse University where he held the Dual Professorship in Chemistry and Science Education. His doctorate was taken in the Chemistry Department of Columbia University. After some years of research in teaching in this Department, he turned his attention to the problems of professional education. Since then, he has held teaching positions in Teachers College, Columbia University; Ohio State University and Syracuse University. He organized and directed at Syracuse a center of science club activities of The American Institute of the City of New York.

ANNUAL MEETING OF THE AMERICAN ASSOCIATION OF JUNIOR COLLEGES

The twenty-first annual meeting of the American Association of Junior Colleges will be held at the Stevens Hotel, Chicago, Feb. 27 to March 1, 1941, according to announcement by Walter C. Eells of Washington, D. C., secretary of the association.

President Robert M. Hutchins of the University of Chicago will be the banquet speaker Friday evening, Feb. 28.

Two topics will predominate in the program. One will be terminal education—that is, what courses should the junior college offer for the student who will have only two years of college? The other will be the place of the junior college in education for the national defense.

Dean William H. Conley of Wright Junior College, Chicago, has been appointed chairman of the committee on local arrangements. The Illinois Association of Junior Colleges, of which Dean Conley is president, has appointed special committees and is making plans for the largest convention ever held.

MR. CHIPS TEACHES GEOMETRY

JOHN J. SHEA
Matawan Township Public Schools, Matawan, New Jersey

(*As curtains part, the teacher is seen seated at his desk correcting papers or busying himself in some other professional way. Bell rings. After a short wait, the class makes a natural entrance by twos and threes. They engage in general whispered conversation and gradually become noisy*)

TEACHER. (*Rapping for order*) Let's have it quiet, please. (*Rises and looks the class over carefully*) Are you chewing gum, Fairfield?

FAIRFIELD. Yes sir.

TEACHER. That's why you can't think. You concentrate too much on chewing gum. Throw it in the basket. (*Fairfield goes to metal waste basket and drops a chunk of hard candy with a loud bang*) Did you say that was gum?

FAIRFIELD. Yes sir.

TEACHER. It sounded like a piece of pig iron. (*Class laughs heartily at this and all of teacher's jokes throughout the skit. Picks up class register and starts calling roll*) Anderson.

ANDERSON. Here.

TEACHER. Burlew.

BURLEW. Here.

TEACHER. (*Calls two or three more names and the students answer "here." Then Skinner, a tall, lanky, "anything for an easy life" youth strolls in very nonchalantly*) Skinner! You're late.

SKINNER. (*Very much surprised*) I am!

TEACHER. You am. (*Class laughs*) Have you an excuse?

SKINNER. (*Never lost for an answer*) I was on hall duty outside the study hall during the passing of classes and there was considerable indigestion down there.

TEACHER. Considerable indigestion! You mean considerable congestion.

SKINNER. No. I mean considerable indigestion. There was so much congestion down there I got considerable indigestion. (*Class registers disapproval of joke with a chorus of "Oo-o-o-o"*)

TEACHER. I've heard worse jokes but I can't remember where. (*Class laughs*) Let this be the last time you come to class late without a written excuse. Take your seat. (*Continues calling the roll and reaches the name of "Harris," a colored boy of the*

"Rochester" type) Harris. (*No answer*) Harris! (*Still no answer*). Is Harris here? (*A loud snore is heard*)

LAWRENCE. (*Smallest member of the class pipes up*) He's here. (*More snores by Harris*)

TEACHER. (*Looks Harris over*) To quote my old friend "Bill" Shakespeare, "Ambition should be made of sterner stuff." (*In a very loud voice*) Harris!!

HARRIS. (*Awakes with a jump*) Yes sir.

TEACHER. Are you here?

HARRIS. (*Still in a daze*) What class is this?

TEACHER. 10th Geometry II.

HARRIS. (*With great assurance*) Then I'm here. (*Pause*) And rarin' to go.

TEACHER. Rarin' to go back to sleep. (*Class laughs. Finishes calling roll. Then goes through business of getting ready for class recitation*) Yesterday we were discussing a new topic, locus. During the course of the period, you were exposed to several constructions which should help you to solve future locus problems. Before we take up any new work, let's review some of the things we discussed yesterday. What does this word "locus" mean. Miss Conrad?

MISS CONRAD. The word "locus" is the Latin word for place. When we speak about the locus of a point we mean the place where we can find all the points that satisfy a given condition stated in the problem.

TEACHER. (*Trying to catch somebody napping*) Do you agree with her, Thompson?

THOMPSON. (*Very much confused*) I-I-I—didn't hear what she said.

TEACHER. I thought so. You looked as though you were dreaming.

THOMPSON. I wasn't dreaming but I was thinking about a dream I had last night.

TEACHER. You should be thinking about geometry, not about your dreams.

THOMPSON. Well I was thinking about geometry, too. I was thinking that maybe if I knew a little more geometry than I do, I wouldn't have had to work so hard in my dream last night.

TEACHER. This is beginning to sound interesting. If somebody got you to do some work, I'd like to hear more about him because he's a better man than I am. (*Class laughs*) Let's hear what your dream was all about.

THOMPSON. Well, last night I dreamt I was fishing in Cheesequake Creek (*localized for laughs*) when along came Majahara (*a magician who had recently entertained the student body*). He asked me if I had caught any fish and I said, "Quite a few." He said, "I'm pretty hungry, young fellow. If you make a fire and cook me some of those fish, you won't be sorry." So I made a fire and we had an old-fashioned fish fry. When we finished, he gave me a piece of paper and said, "Follow the directions on this paper and they will lead you to some of Captain Kidd's buried treasure." I glanced at the paper to see what was written on it. When I looked up, Majahara was gone and in his place were a pick and shovel. I was sorry that he had disappeared, but I was too anxious to find the treasure to waste any time looking for him. I threw the pick and shovel into my boat, hopped in, and rowed up the creek to a spot mentioned on the paper. When I got there, I followed the directions carefully. I dug and I dug and I dug. All night long I dug, but I woke up this morning without finding the treasure.

TEACHER. That's an interesting dream but what makes you think that geometry might have helped you to find the treasure?

THOMPSON. I think that if I had known something about locus, I would have found the spot where the treasure was buried right away, and I wouldn't have had to dig all night for nothing.

TEACHER. Maybe you're right. Do you remember what the directions were?

THOMPSON. I think I do.

TEACHER. Let's hear them.

THOMPSON. They went something like this: "Starting at a skull and bones mark on the bottom of a black rock on the shore of Cheesequake Creek near three trees and Applegate's Brook, go sixty paces in a line due east. There drive a stake. Locate a point thirty paces from this stake and twenty paces due south of the line between the mark on the rock and the stake. There you will find the treasure."

TEACHER. I think the directions on that paper were sufficient to determine the position of the treasure.

THOMPSON. That's what I thought.

TEACHER. Let's make a drawing to show how to locate that treasure. Did you find the mark on the black rock near three trees?

THOMPSON. Yes sir.

TEACHER. Then the first thing to do is to choose a point to represent that mark. Go to the board and do that, will you Anderson? (*Anderson goes to board and chooses a point*) What does that point represent, Anderson?

ANDERSON. That point represents the skull and bones mark on the bottom of the black rock.

TEACHER. What's the next thing to do, Clark?

CLARK. Locate the point that is sixty paces due east of that point.

TEACHER. Before he does that, Burlew, what would you advise him to do?

BURLEW. Well, the first thing I'd do would be to name that point on the board.

TEACHER. That's a good idea. What do you suggest calling it, Burlew?

BURLEW. I'd call it *R* to keep in mind the fact that the rock is located at that point.

TEACHER. A good suggestion, Burlew. Name that point *R*.

ANDERSON. (*Anderson names point*) Are we now ready to locate the point that is sixty paces due east of the rock, Miss Conover?

MISS CONOVER. I don't think so. I think we should first choose some convenient unit of measure and let it represent ten paces.

TEACHER. That's another good suggestion. Let's have a unit of measure, Anderson. (*Anderson chooses a unit and labels it 10 paces*)

TEACHER. Now are we ready to locate the point that's sixty paces due east of the mark on the rock, Burlew?

BURLEW. Yes Sir.

TEACHER. Find that point for us Anderson, and explain each step as you go along.

ANDERSON. Starting at *R*, I draw a line of indefinite length due east. (*Action*) Starting once again at *R*, I'll lay off a segment on the line of indefinite length that's equal to sixty paces. (*Action*) The other end of this segment I'll call "*S*."

TEACHER. Have you any special reason for naming that point "*S*"?

ANDERSON. It will help us to remember that the stake is located at that point.

THOMPSON. Mr. Chips, the directions said to drive a stake sixty paces east of the rock.

TEACHER. Raise your hand if you have something to say, Thompson.

THOMPSON. Yes sir.

TEACHER. Thompson wants you to drive a stake sixty paces east of the rock, Anderson. (*Anderson pictures the stake*) The stake is driven. What shall we do now, Miss West?

MISS WEST. Find the locus of points that are twenty paces due south of *RS*.

TEACHER. Describe that locus, Lawrence.

LAWRENCE. It's a line parallel to *RS* and twenty paces due south of *RS*.

TEACHER. Construct that locus, Miss West, and explain each step in the construction before you take it.

MISS WEST. I choose a point on the line *RS*. I name the point *A*. With *A* as a center and with any convenient radius, I describe an arc intersecting *RS* in two places. I name the points of intersection *M* and *N*. With *M* and *N* as centers and a larger radius, I describe arcs intersecting each other. I name the point of intersection *Z*. Then I draw *AZ*.

TEACHER. That's very good, Miss West. Who'll carry on with the construction? (*Lawrence volunteers*) All right Lawrence.

LAWRENCE. (*Goes to board to continue the work. These constructions are explained and performed one step at a time*) Starting at *A*, I mark off a distance on *AZ* that represents twenty paces. The distance from *A* to this point (*gestures*) equals twenty paces. I name this point *O*. Using the same construction which Miss West used, I shall erect a perpendicular to the line *AZ* at the point *O*. (*After finishing this step*) I name this line *CD*.

TEACHER. What do you know about *CD* Lawrence?

LAWRENCE. I know that *CD* is parallel to *RS*.

TEACHER. How do you know that?

LAWRENCE. (*Pointing out as he talks*) Earlier in the course we proved that straight lines in the same plane perpendicular to the same line are parallel.

TEACHER. All right, Lawrence, you may sit down. Of what use is the line *CD*, Miss DeForest?

MISS DEFOREST. All the points that are twenty paces due south of *RS* are located in that line.

TEACHER. That is to say, Fairfield?

FAIRFIELD. Every point on *CD* is twenty paces due south of *RS*.

TEACHER. So we know now where to find all the points that

are twenty paces due south of the line between the mark on the rock and the stake. Where shall we find all the points that are thirty paces from the stake, Clark?

CLARK. We shall find all the points that are thirty paces from the stake in a line circle whose center is the stake and whose radius is thirty paces.

TEACHER. Go to the board and draw that circle Miss DeForest.

MISS DEFOREST. First of all, I'll draw a working line. On this working line I'll lay off a distance that's equal to thirty paces. With *S* as a center and with this distance as a radius, I'll describe a circle. I'll name this point of intersection *T*.

TEACHER. Why do you call that point "*T*"?

MISS DEFOREST. Because that's where we'd find the treasure.

TEACHER. Do you agree with her Skinner?

SKINNER. Yes sir.

TEACHER. Go to the board and explain just why you would dig for the treasure at the point *T*.

SKINNER. Point *T* is in the line *CD* and we know that every point in the line *CD* is twenty paces due south of the line *RS*. Point *T* is also in the line circle whose center is *S* and whose radius is thirty paces, and we know that every point in this circle is thirty paces from the stake. So *T* is a point that fulfills the conditions stated in the directions which Majahara gave Thompson and if Thompson had dug there, he would have found the treasure.

TEACHER. (*Thompson raises his hand*) Yes, Thompson?

THOMPSON. Mr. Chips, how could I have made all those constructions?

TEACHER. You said you were fishing, didn't you?

THOMPSON. Yes sir.

TEACHER. Then I suppose you had a fishing line. Is that right?

THOMPSON. Yes sir.

TEACHER. You see me after class, and I'll show how you could have used your fishing line in making those constructions.(*Looks at his wrist watch*) Well, it's almost time for the bell. Before the bell rings, however, who will sum up in one good sentence the one big thought that we should carry away with us today. (*Harris, the colored boy raises his hand*) Do you mean to tell me that you stayed awake all through this, Harris?

HARRIS. (*A little insulted*) Yes sir.

TEACHER. I'm almost afraid to ask you but I'll take a chance.

What is the one big thought that we should carry away with us today?

HARRIS. If you study geometry, you won't have to work while you sleep.

(*Everybody including teacher faints*)

CURTAIN

ADAPTATION OF THE DEMONSTRATION LABORATORY TO THE HIGH SCHOOL

CARL A. BENZ, Hammond High School, Hammond, Ind.

It is a matter of common knowledge that three difficulties with teaching physics successfully in many high schools are (1) lack of equipment or lack of duplication of equipment (2) shortened time allotment (3) increased enrollment. All of these have for obvious reasons caused an increase in the use of the demonstration method in the classroom in preference to individual laboratory work. Many times however, an instructor will perform a demonstration with the students preferring to do it themselves. This is made obvious by noting the numerous times a portion of the students remains after class to push a lever or pull a switch for a repetition of the demonstration.

The desire to give the students more first hand contact with the equipment has led to a plan at our high school of setting up a series of demonstrations on a given section of physics such as "Heat and Temperature." This plan is an outgrowth of visits made to the Demonstration Laboratory at the University of Chicago. The students are given written directions on each of the demonstrations which are about ten in number and then sent to the laboratory where they may perform the experiments either singly or in pairs. If the class is large, half may go one day while the other half completes a reading assignment in the classroom. The "writeup" is a simplified question type designed to direct the student into the experimental method of finding out scientific principles.

This plan allows the student to see first hand the phenomena desired and avoids the necessity for having many sets of the same apparatus. Current purchases may be directed toward accumulating a wider variety of equipment and some of it may be set up permanently if space is available and duplication of clamps and ordinary essentials is allowed. By a wide variety I refer to several demonstration pieces which will enrich the teaching of what we do teach and help do it more thoroughly rather than to bring in more topics of physics.

Since space is not available and duplication of essential equipment at our school is not feasible as yet, it is not possible to leave the demonstrations set up permanently, but a given series may be set up as long as is necessary for the study of the given section. The equipment may be left up so that during the study of the section, a student may go to the laboratory and reaffirm some of the answers to certain questions not fully settled in his own mind.

A good professor is a student who can also teach.—DANIEL COIT GILMAN.

SOME SIGNIFICANT CONCEPTS AND BELIEFS IN ASTRONOMY AND GEOLOGY OF ENTERING COLLEGE FRESHMEN AND THE RELATION OF THESE TO GENERAL SCHOLASTIC APTITUDE

LYNN L. RALYA AND LILLIAN L. RALYA
The Citadel, South Carolina

Few systematic attempts have been made to determine the degree of mastery of specific simple and basic scientific concepts and principles, the prevalence of specific erroneous beliefs and misconceptions hindering possible and desirable lay scientific thinking, and the relationship between general mental ability and the acceptance of correct and rejection of false concepts and principles. This report presents partial results—those concerning astronomy and geology—of an investigation making such an attempt and motivated by the following hypotheses: (1) Many important scientific principles and concepts are relatively simple and could and should be part of the mental equipment of nearly all people; (2) Measuring instruments used to determine the degreee of acceptance of such principles and concepts and the prevalence of erroneous beliefs should be made up of items chosen not by random sampling of subject matter, but by judicious and careful selection of such concepts as conceivably could be almost universally mastered and of such basic misconceptions as are known or suspected to be prevalent.

It is believed that the results of this and similar investigations might lead, in due time, to improvement in science teaching on all educational levels comparable to the improvement in language teaching brought about by study of the relative frequency of errors in English usage and in arithmetic teaching by the determination of the relative difficulty of arithmetical processes.

Astronomy and geology are seldom encountered as separate subjects by students below the college level. However, it is to be recognized that some of the simpler concepts, often of greatest functional significance, have been met in geography, in elementary or general science, or in physics. Nor should we fail to realize that folk beliefs, encountered both without and within the school, are potent in engendering and maintaining both true and false concepts and beliefs.

Sources of Data

Data concerning specific concepts and principles and erroneous beliefs were obtained by means of a 232-item "Science Inventory." The 52 items pertinent to astronomy and geology are to be considered here. The sources of the items were four in number: (1) Many were repetitions or modifications of items previously used in a study of basic misconceptions in science of prospective elementary teachers;[1] (2) Some not previously used were derived from analyses of state courses of study in elementary science—the sources of all items of the study above mentioned; (3) Some were suggested by the book, *The Story of Human Error*, edited by Joseph Jastrow;[2] (4) Some were suggested by other studies in the prevalence of erroneous beliefs, misconceptions, and superstitions. General scholastic aptitude was judged by scores on the American Council Psychological Examination.

The Science Inventory and the American Council Psychological Examination were given to the entering Freshmen at a state college for men located in the southeast and enrolling about a thousand students. Both were given as part of the testing program during Freshman Week with about fifteen proctors present during the administration of each. Both were administered, therefore, under normal, standard conditions—a fact which allows legitimate comparative treatment. Nearly all subjects finished the items on the Science Inventory in the hour allotted. The data of this report were obtained from the papers of the 325 subjects who completed both tests under the conditions described.

Treatment of Data

The results of the psychological examination revealed that the subjects of this study averaged about the same in scholastic aptitude as the Freshmen in other colleges and universities in the region.

For each item included in the Science Inventory the per cent of incorrect responses was computed (1) for all 325 subjects; (2) for the 100 subjects scoring highest on the psychological examination; and (3) for the 100 subjects scoring lowest on the psychological examination.

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[1] Lynn L. Ralya and Lillian L. Ralya, "Some Misconceptions in Science Held by Prospective Elementary Teachers" in *Science Education*, XXII, 5 (October, 1938), pp. 244–251.

[2] Joseph Jastrow, Editor, *The Story of Human Error*, D. Appleton-Century Company, New York, 1936.

RESULTS ON SCIENCE INVENTORY ITEMS CONCERNING ASTRONOMY AND GEOLOGY

No.	Item	Per Cent of Subjects in Error		
			Schol. Apt. Groups	
		All 325	Upper 100	Lower 100
1.	The earth is a planet.	3	1	3
2.	Mars is a planet.	1	0	1
3.	The sun is larger than the earth.	3	2	2
4.	The earth is bigger than any other body circling about the sun.	16	7	20
5.	The earth is located at the center of the universe.	15	5	23
6.	The sun is bigger than any other body in the universe.	62	43	67
7.	The heavenly bodies exist to give light to man.	42	26	56
8.	There are many million stars.	4	4	6
9.	The stars are much closer to each other on the average than are the earth and sun.	45	25	61
10.	The solar system does not occupy a thousandth of the space of the universe.	32	19	36
11.	Meteors ("falling stars") are sometimes out among the distant stars when we first see them.	62	52	67
12.	The sun is a star.	62	39	74
13.	The distant stars shine because they are hot like the sun.	53	36	60
14.	The matter composing the earth was once a part of the sun.	46	31	50
15.	The stars contain few, if any, chemical elements not found on earth.	43	38	42
16.	Faint stars are always farther away than bright stars.	16	7	23
17.	We see a full, a half, and a quarter moon because there are several different moons travelling about the earth.	2	0	2
18.	The milky way consists of a cloud in the sky.	11	8	17
19.	The sun is fixed in position in space.	53	52	51
20.	The distant stars are fixed in position in space.	30	26	39
21.	It is more natural for a body to stop itself than to set itself in motion.	66	57	66
22.	The paths taken by the planets in travelling around the sun are perfect circles.	34	15	45
23.	It is merely because of the movement of the earth that a distant star appears to the naked eye to move.	48	42	50
24.	The earth circles about the sun in a year.	14	7	19
25.	The moon travels about the earth in approximately a month.	20	8	35
26.	The moon shines by light reflected from the sun.	12	3	17

No.	Item	Per Cent of Subjects in Error		
			Schol. Apt. Groups	
		All 325	Upper 100	Lower 100
27.	The stars are not visible in the day time because our side of the earth is turned away from the direction in which they are found.	15	7	21
28.	On a very cloudy day no light from the sun reaches the surface of the earth.	6	4	10
29.	Light will travel through a vacuum.	20	15	25
30.	Light travels instantaneously from the sun to the earth.	27	9	52
31.	A shadow is a place from which light has been shut off.	14	17	16
32.	The handle portion of the Great Dipper points toward the North Star.	60	50	71
33.	Since the earth was formed there has been no upward movement of the earth's crust which has tended to compensate for the wearing away of the mountains.	28	16	37
34.	The formation of stratified (layered) rock is going on to-day.	6	4	7
35.	The earth is millions of years old.	10	5	13
36.	Man has been on earth for at least fifty thousand years.	30	18	39
37.	The temperature increases as we dig deeper and deeper into the earth.	40	30	52
38.	The center of the earth is a sphere of fire.	27	24	28
39.	Coal is made from plant material.	6	0	11
40.	Fossils are the remains of animals drowned during the Flood.	22	15	28
41.	The Northern Hemisphere of the earth is tipped toward the sun during our summer.	28	25	20
42.	The seasons are caused by the varying distance of the sun from the earth.	79	64	89
43.	The moon is largely responsible for tides.	7	2	8
44.	A fog is a cloud close to earth.	34	25	39
45.	If air is warmed, its capacity to hold moisture is increased.	25	19	24
46.	The atmosphere exerts pressure only when a wind is blowing.	5	2	8
47.	The pressure of the atmosphere against a square inch at sea level averages about fifteen pounds.	20	15	28
48.	The weight of the atmosphere above a square inch at sea level averages about fifteen pounds.	44	40	46
49.	The stars greatly influence the destinies of men.	22	13	32
50.	Lunacy grows worse at full moon.	15	7	23
51.	There will be little rain when the points of the moon turn up.	14	8	23
52.	The weather always clears up after a rainbow.	29	17	36

The correlation coefficient obtained when the positive scores on the Science Inventory and the positive scores on the psychological examination were used was .59. This figure indicates that the relationship between gross achievement on the two examinations was approximately equivalent to ascertained correlations between accomplishment in any one school subject and general scholastic aptitude.

The results obtained for the 52 items concerning astronomy and geology are presented in the table.

Interpretation of Results

A study of the items listed above will show that with one or two exceptions they are stated positively, whether directed at the measurement of the prevalence of desirable concepts and principles or of erroneous beliefs. Moreover, most, if not all, are concerned with material so simple in character that some degree of understanding, conviction, belief, or bias will be present in the minds of most subjects. As positive stating tends to guard against errors made because of mere mental confusion, so the familiarity of the material tends to reduce random guessing.

A. Results in Astronomy

Of great influence on man's conception of his own significance and destiny have been his beliefs concerning the magnitude, relationships, and behavior of the heavenly bodies. This influence may be less, relatively, to-day, because of the vast expansion of other fields of scientific knowledge; but it surely remains in sufficient degree to warrant our concern about concepts and beliefs in this field.

Although apparently few, if any, subjects entertain the once universal geocentric view that the earth is larger than the sun (3),[3] there is evidence of some acceptance of the belief that the earth is larger than any other planet (4). Acceptance of this error is more prevalent among subjects scoring low on the American Council Psychological Examination than among those scoring high, since 20% of the lower group and 7% of the upper group respond incorrectly. A more striking difference between the upper and lower groups is shown by the responses to the extreme geocentric notion that the earth is located at the center of the universe (5). The heliocentric belief that the sun

[3] Numbers in parentheses refer to item numbers in the table.

is the largest body in the universe is accepted by 62% of the total number of subjects (6). Comparison of upper and lower groups on this point offers no very striking contrast, since 43% of the upper group and 67% of the lower group accept the item as true. It is of significance that 42% of the subjects have the homocentric point of view that the heavenly bodies exist to give light to man (7). The fact that the number in the lower group entertaining the belief is more than twice that in the upper group is scant comfort to the science teacher.

Nearly all these subjects have some conception, however vague, of the vastness of the universe, for all but 4% subscribe to the statement that there are many million stars (8). However, with many this conception does not reach the elementary expansiveness that it could and should, since they give evidence of lacking rudimentary comprehension of the distances and spatial relationships involved. The belief that the stars are much closer to each other than the earth and sun is subscribed to by 45% (9); it is believed by 32% that the solar system does not occupy a thousandth of the space of the universe (10), and 62% believe that the "falling stars" are out among the distant stars when we first see them (11). All of these misconceptions exist to a greater degree among the lower group than among the upper group; yet in each case the prevalence among the upper group is high enough to justify concern.

Of tremendous significance in any philosophy of the universe, even of the garden variety, is, or should be, the modern scientific conviction of the unity of the universe. We find here that, on the average, about half these subjects subscribe to true statements dealing with aspects of this unity. About half accept the statement that the distant stars shine because they are hot like the sun (13), and 54% accept the present scientific view that the earth was once part of the sun (14). A somewhat larger per cent of the subjects reject the statement that the sun is a star (12); in fact, 74% of the lower group and 39% of the upper group consider the statement false, thereby disclosing lack of even an elementary comprehension of the relation of the solar system to the other heavenly bodies. Some conception of the chemical unity of the universe is possessed, apparently, by the 57% who subscribe to the statement that the stars contain few, if any, chemical elements not found on earth (15).

The universal and unceasing movement of the heavenly bodies is not realized by more than half these subjects, for 53%

of them endorse the statement that the sun is fixed in position in space (19). It is significant too that the responses to this item show no differentiation between the upper and lower groups. Moreover, 30% believe that the distant stars are fixed in position in space (20). Failure to grasp the cause of unceasing motion as expressed in the Newtonian principle of "inertia" is revealed by the 66% who consider it true that it is "more natural" for a body to stop itself than to set itself in motion (21). This fallacious concept is apparently prevalent to a high degree among subjects both in the upper and lower groups in scholastic aptitude. It is significant likewise that 34% cling to the old Copernican view that planets move in perfect circles (22) and that, according to our data, the ratio of the prevalence of the belief in the lower and upper groups is 3:1.

Over one-fourth of the subjects believe that light travels instantaneously from the sun to the earth (30). This item, apparently, has great discriminatory value with respect to general scholastic aptitude, since only 9% of the upper group accept it as true, while 52% of the lower group subscribe to it.

B. Results in Geology

One of the important intellectual needs of those who are to grasp an understanding and gain an appreciation of the processes of variation and natural selection occurring in the historical development of life on earth is some degree of comprehension of the time element involved. All but 10% of these subjects concede the earth an age of millions of years (35). However, 30% would not allow man the modest age of even 50,000 years (36).

Of significance as illustrating a type of weakness often found in the outcome of science instruction is the fact that although 72% accept the fact that the Northern Hemisphere is tipped toward the sun in our summer (41), apparently not more than 21% conceive of this fact as the cause of our seasons (42); for 79% endorse the belief that the seasons are caused by the varying distance of the sun from the earth. There is, moreover, an exceptionally high per cent of acceptance of this current fallacy in both the upper and lower groups. A somewhat similar type of weakness is revealed by responses to items 47 and 48. While all but 20% agree that the pressure of the atmosphere above a square inch averages about 15 pounds (47), 44% reject the statement that the weight of the atmosphere above a square inch at

sea level averages about 15 pounds (48). Evidently a significantly large per cent of the students even in the upper group have failed to establish an understanding of the relation of the two concepts, weight and pressure.

The unfounded beliefs embodied in items 49, 50, 51, and 52 have significant prevalence. Over a fifth of the group would have mental readiness for some form of astronomical quackery, and the persistence of folk-beliefs even in the upper group is apparent.

Summary and Conclusions

This study has dealt with the reactions of 325 entering college Freshmen to each of 52 correct concepts or erroneous beliefs in astronomy and geology. For each of the 52 items the responses (1) of the total 325 subjects, (2) of a group of the 100 subjects ranking highest in scholastic aptitude, and (3) of a group of the 100 subjects ranking lowest in scholastic aptitude have been presented. Since this study is concerned chiefly with reactions to specific statements rather than with general performance, but few generalizations can be made concerning its findings. It may, however, be said (1) that the relative prevalence of specific concepts and specific erroneous beliefs in a designated group have been determined with some objectivity; (2) that the degree of prevalence of a misconception or unfounded belief offers no reliable index of the degree of prevalence of closely related concepts and beliefs; and (3) that while there is evidently a significant and positive correlation between freedom from misconceptions and general scholastic aptitude, this relationship furnishes no index to the prevalence of any one specific concept or erroneous belief among members of groups of relatively high or low scholastic aptitude.

It is believed that at least the great majority of concepts and principles represented by the items used in this study are basic to clear thinking and, furthermore, could enter effectively into the every-day thinking of nearly all high school graduates. When we compare the simplicity of the items used here with the relative complexity of much of the material presented in high school science courses, we begin to realize that the task of evaluating the functional worth of the multitudinous concepts in the school sciences, though an onerous and precarious one, must yet be assumed by those committed to the improvement of science teaching.

A PROJECT IN CHEMISTRY

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In order to keep up the interest developed by certain students in their high school chemistry, a Special Chemistry was offered to those who could work it into their schedules profitably.

As it is organized now, no credit is offered. The course consists entirely of laboratory work. The instructor is given no time for the work. Any help or direction given is sandwiched in between the other classes, during study periods, vacant periods, or noon hours. The students come into the laboratory at various hours during the day when the regular classes of chemistry are not using the laboratory. An attempt is made to schedule the special students for an hour that at no time would conflict with the regular classes, but sometimes this is not always possible.

At the present time there are eight students availing themselves of this opportunity. When this project was started three years ago, there were three students who followed the work for the entire year.

Most of the people involved are boys that plan to go on in some field of chemistry. There have been two girls who were planning to enter nurses' training who took the work. A connected program of laboratory work was planned that dealt directly with chemistry for nurses. The fact that the instructor had at one time taught classes of chemistry in a nurses' training school made this particularly easy.

An attempt is made to give an introduction to the fields of organic, qualitative, and quantitative chemistry during the year. A selected list of experiments has been made up in each of the three fields mentioned. It has been found that as a rule the organic field holds more interest for the students, with qualitative analysis coming next, and quantitative analysis receiving the least emphasis.

Because of limited equipment some of the students will be working in quantitative analysis, others in qualitative, and others in the organic field all at the same time. By having the students work in a staggered fashion a limited amount of equipment can go a long way. Too, it gives the student a sense of independence to see that he is the only one preparing di-

ethyl ether or determining the percentage of copper in copper sulfate.

The students are advised that to do as much reading as possible on the particular problem would make their work more profitable. Nothing, however, is compulsory, Several well selected references on each of the fields of chemistry covered in the project are kept in the laboratory for ready reference.

No tests are given. The student is not made to feel that a certain amount of work must be done at a certain time. Each student works at his own pace. A grade is given at the end of each six week's period, however, with a "no credit" stipulation on the card. This grade serves as tangible evidence of having done something that others have not done.

Over the period of three years' time an outline of work has been built up that fits in with a very limited amount of inexpensive equipment, a crowded laboratory, and limited time. Any good first year college laboratory manuals for qualitative, quantitative, and organic chemistry can serve as a basis for formulating the outline of work.

Following is the outline of work that has been found to be very satisfactory for the conditions of the school in which the project is working:

Organic experiments

1. Fractional distillation of alcohol
2. Preparation of absolute alcohol
3. Preparation of di-ethyl ether
4. Preparation of thiocarbanilid
5. Preparation of sulfanilic acid
6. Preparation of acetanilide
7. Preparation of acetamide
8. Preparation of benzoic acid
9. Preparation of aniline
10. Preparation of nitrobenzene

Quantitative experiments

1. Law of Definite Proportions
   Part a. To show that a definite amount of given substance unites with a fixed amount of a second substance to form a compound
   Part b. To determine the percentage composition of a compound
   Part c. To determine the simplest formula of a compound
   Part d. To find the equivalent of an element, and the valence
   Note 1: In the above experiment a weighed quantity of magnesium was burned and the data gathered from that source.
2. Determination of water of crystallization in copper sulfate
3. Determination of copper in copper sulfate
4. Determination of aluminum in alum

Qualitative experiments

1. Selected unknowns from the Hydrochloric Acid Group and from the Hydrogen Sulfide Group

The number of unknowns run will depend on the speed with which the student works. Any of the more elementary schemes of analysis will serve as guides. The above list of experiments has been found to constitute about a year's work, assuming that the student can spend one hour each day in the laboratory.

No school that offers chemistry, regardless of how small, need feel that too much equipment is necessary. In the school where this project is being carried on, the only item of equipment that might not be found in all high school chemistry laboratories is an analytical balance costing around seventy-five dollars. The fact that a school does not possess an analytical balance need not prevent the teacher from inaugurating this interesting and stimulating project in the field of qualitative analysis and organic chemistry.

During the past three years in which this project has been carried on, the yearly budget for chemistry has not exceeded sixty dollars. The materials for the regular classes of chemistry have been paid for from this same yearly budget of sixty dollars. The average number that have taken chemistry in the past three years is sixty-two. This number is divided into two classes. The greatest number doing the special chemistry is eight.

Only those students are permitted to enroll who are above average in their first year's chemistry, who are sincere in their desire to do the work, who can be relied upon to work independently, and whose behavior in the unsupervised laboratory is unquestioned. It might be stated at this point that to date no accident has occurred in the laboratory because of horse play or carelessness.

The values of this project are many. If it were to just keep up the interest of those doing the work, that in itself would be justification enough for continuing the project. However, there are other values; that of developing a laboratory technique that enables the student to attack in a more satisfactory manner his subsequent college chemistry; that of developing the spirit of independence and the ability to go ahead on one's own initiative; that of stimulating the students who are taking the regular high school chemistry. Students in the first year classes are constantly asking if they might be allowed to enroll for Special Chemistry next year.

ON THE RESPONSIBILITIES OF TEACHERS WITH SPECIAL TRAINING IN SCIENCE

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Recently at a small gathering I was introduced to a lady of middle age or past. Previous to our meeting she had known nothing of me, nor I of her. In the course of small talk the question came up, "What do you do?" I answered that I was in university work and interested in the education of science teachers. She hastened to reply: "Oh, you're in science. Well, I've always tried to stay away from that." I could not resist asking if she had been successful. After a moment's reflection she said she guessed not. As the conversation went on, it appeared that science to her meant the course in physics she had had in high school.

By reviewing an experience that is fairly representative of the results that accrue from science teaching, we may understand how such an attitude on the part of an adult could have developed. An interview[1] with a girl seventeen years of age, I.Q. 115, who had studied physics in a twelfth grade class under instruction carefully planned to develop the concept of mass, shows something of the difficulties young people are facing:

Q. When you talk of the *mass* of a body, what do you mean?
A. The quantity of matter it contains.
Q. What do you mean by "quantity of matter"?
A. The amount of material in it.
Q. How would you know which of two objects contains more material in it?
A. The larger one would.
Q. So, amount of material, or mass, is the "volume" of the material?
A. No, mass is not volume.
Q. Well, you said the larger one.
A. I mean the heavier one.
Q. So, you mean mass is weight?
A. No, it is not weight.
Q. Well, you said the heavier one.
A. The heavier one will have more mass, but mass is not weight; gravity has nothing to do with mass.
Q. Then what is mass?
A. I never did understand what it was.
Q. Did you like to learn about weight, mass, and gravity?
A. Yes, but it was too difficult.
Q. But I think you understood everything, did you not?
A. No.

[1] National Society for the Study of Education. *Thirty-first Yearbook*, Part I, pp. 70–71. Public School Publishing Co., Bloomington, Ill., 1932.

Q. But you know what gravity is and what it does?
A. Yes.
Q. And what weight is?
A. Yes.
Q. And mass?
A. No, I never did see that.

After this experience with mass, weight, and gravity, and other experiences with ohms, joules, and faradays, this girl and thousands of other boys and girls may say: "From now on I shall try to stay away from that."

It is not surprising that there are some things wrong with science teaching. During the nineteenth century, science, physics in particular, came to occupy a place in the schools as part of the education of a privileged minority in a pre-industrial society. The education that evolved to meet the conditions of a society that was still largely feudal is not appropriate for a modern democracy.

We have been concerned, in our work in the Bureau of Educational Research in Science at Teachers College, Columbia University, with changing science teaching so as to make it conform to the needs of the young people in our present-day society. Through financial support given by the General Education Board, we have been able to make definite progress. This made it possible to enlist the services of a number of specialists representing different sciences who gave their whole time to making a study of the question. These specialists—physicists, chemists, biologists, and others—kept in close touch with one another, and the project has been thoroughly cooperative. A number of reports[2] designed to make science teaching more effective have been issued, and we are following up our recommendations with empirical inquiries aimed at discovering how the recommendations work out in practice and how they should be modified in order to attain greater improvement in the quality of our service to young people.

In approaching their task, the members of this science group decided first to ask what are the chief shortcomings in science teaching. In their opinion these are many, even when science teaching is regarded only as a preparation of specialist workers in particular sciences. When regarded from the point of view of the broader purposes of general education, the shortcomings are much more numerous.

[2] The "Science in Modern Living" Series. Bureau of Publications, Teachers College, Columbia University, New York.

The main shortcomings[3] of present science teaching, looked at from the point of view of specialist training, seem to be:

1. That there is far too little correlation between the different sciences.
2. That in all sciences there is emphasis on the abstract formulations of theory before sufficient practical experience has been gained in the situations to which theories refer.
3. That there is insufficient emphasis on the conditions which have to be fulfilled before valid scientific generalizations may be made (scientific caution, etc.).
4. That insufficient attention is given to the basic, methodological problems (e.g., problems of classification, of measurement, of defining concepts and units, of statistical problems, etc.).
5. That there is insufficient encouragement given young people in the practice of scientific methods through the pursuit of real problems.
6. That too little is done to bring young people to appreciate the part unambiguous formulation and communication of principles play in science.

Of the further shortcomings to be remedied in order to serve more effectively the broad purposes of general education, perhaps the most important are:

1. That science teaching fails to give young people a sufficiently clear understanding of the physiology of their own bodies and the conditions of personal and social health.
2. That science teaching fails to give a coherent picture of the world as revealed by science.
3. That too little is done to bring young people to appreciate the applicability of scientific methods to practical problems of all kinds, including psychological and sociological problems.
4. That there is insufficient reference to the practical aspects of science, both with regard to its place in social history and with regard to the part it is playing in the transformation of the world.
5. That young people are not brought to recognize sufficiently clearly the way in which society is dependent upon natural resources and technology.
6. That young people are not brought to recognize the major problems confronting society in which science may help.

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[3] Powers S. R. "Improvement of Science Teaching." *Teachers College Record*, p. 275, January, 1939.

7. That too little is done to teach science so as to free young people from traditional feelings of fear and guilt, as well as from the influence of quackery, whether commercial, political, or religious.

Most science teachers will, I suppose, accept these criticisms as substantially valid and will offer excuses for not doing a better job in meeting them. Some will say there isn't time to do these things, or the "kids are too dumb," or the colleges or the superintendent or somebody won't permit changes, or the criticisms and suggested changes are made by theorists and are impractical, and so on. But if we come right down to it, the truth is, most of us don't know how to do these things. We stumble into science teaching after preparing for research, for engineering, medicine, or just preparing, so we are not properly educated for our jobs. In many cases we haven't been very good students of the job after beginning our work as teachers.

As a first step in the improvement of science teaching, teachers must take a more critical attitude toward their own work. They must ask themselves what they are trying to do to the young people who come to their classes and follow the question till it leads them through subject matter to desirable forms of behavior. And then teachers must follow the question still further, seeking all the while estimates of their success in developing these desirable behaviors.

To meet the criticisms it is not only necessary that important changes should be made in the curriculum, it is also necessary that science teachers themselves should acquire a more liberal understanding of science and a clearer conception of its social function. Obviously another important factor in the situation we are analyzing is teacher education, not only of teachers in training, but also of teachers in service.

The chief criticisms of teacher education may be summed up under three main headings:

1. It is said, among other things, that teacher education suffers from the fact that the courses which form its basis are, in substance, those that were originally designed to accomplish the high degree of specialization that is required for research and for work in the scientific professions, especially medicine and engineering, and has not been planned with reference to the teacher's work.

2. At the same time it is said that the pedagogical courses are too often conceived according to ideas of education that now

belong to the past, and vested interests of training colleges are accused of stressing too much the old-fashioned courses in the history and principles of education and in general methods, and of using the support they have from certificating agencies to force large numbers of teachers-in-training to follow them.

3. A further criticism is made on the grounds that teacher education, following on the one hand the special interests of the student in subject matter, and on the other hand his professional preparation—that is, his preparation for the actual work of teaching—is conceived of and conducted along two independent lines, the one in academic subject-matter departments, the other in schools or departments of education. On account of this, the student preparing to teach is often confused by the dual nature of his program and doubly confused when he finds that those concerned with the academic side of his education and those concerned with the professional side are unsympathetic with, and even intolerant of, each other.

We must, I think, admit the validity of these criticisms. Consequently the young people leaving our colleges and graduate schools and going out to teach science can hardly be prepared for their work.

The aforementioned shortcomings of science teaching, when stated positively, may be considered to be objectives. An analysis of one of them may enable us to see the general character of constructive measures to be undertaken. Consider the positive statement of Number 2 in the second list: Science teaching should give to young people a coherent picture of the world as it is revealed by science. In an examination of this objective we may ask: Why is it important in general? What is known about it? What kinds of difficulty and confusion are met by young people in grades eleven and twelve because of their incoherent and unscientific picture of the world? What experiences with materials and methods will help these young people resolve their difficulties and reduce their confusion? How may we evaluate our successes? Let us consider these questions in order.

Why is this objective important? In any culture, the content and sanctions of its religions, its morals and ethics, and its government are affected fundamentally by conceptions of the nature of the universe, of man's place in it, of man's relations to society and to other individuals, and by his conception of his own psycho-physical nature. Such considerations are particularly important today because of conflicts caused by the impact

of science on unscientific beliefs and practices. The modern scientific view is that of a world with virtually no boundaries in space and time and continually changing. In it man is seen as akin to the entire scheme of nature and not as a special creation. This is in sharp contrast with the world-view of the prescientific period—special creation with heaven above and hell below. However strongly young people may deny their acceptance of the anthropomorphic world-view of the past, the conduct of their lives is still much affected by it. Conflicts arise at least in part because individuals, while rejecting the older view, are unable, often through lack of opportunity, to grasp the essential features of the scientific view. Personality suffers from this failure, for the individual is kept from achieving the kind of emotional anchorage which everyone seeks. Science has given us a new world-view and one that is more nearly in agreement with the facts of experience. Science teachers have a responsibility to help young people achieve orientation in this new world-view.

What is known about this? The physical features of the scientific world-view are built up from present conceptions of space, time, matter, and motion. If the teacher is to be effective in helping young people through their difficulties, he must know a great deal about these things and a great deal about how they are related to the difficulties met by people as they seek to make their personal adjustments.

What are the difficulties and confusions of young people? These are shown in the questions they ask and the points that come up in the discussions in which they participate. They want to know:

Is there life on Mars or Venus?
Will we ever be able to fly through space (like Buck Rogers)?
What would happen if the earth were to collide with a meteor or a comet or pass through the tail of a comet?
Is there anything to astrology?
How far away are the stars and how do we know?
What are conditions on the moon?
Is the climate changing?
Are there natural laws?
Is there a master mind controlling the universe?
What is fact? What is fancy? And how do we know?
What valid conclusions may we draw?
What invalid conclusions have we accepted and used in ordering our lives?

What materials and methods may we use? The generalized answer here is that materials and methods will be selected to meet the needs and interests suggested by the questions and problems of young people. It may be said that no one knows the answers to their questions. True, if the questions are carried to a detailed analysis; but if the answers were known they would no longer be questions, certainly they would not be problems. However, science does have a good deal to say about these things. There is a scientific view of the world, and thoughtful science teachers are seeking for themselves an orientation that is free from major paradoxes. They seek this, first, for the personal satisfactions that come from it, but at the same time so that they may help young people to a similar achievement. The science teacher who is well educated in science and who is interested in extending his own understanding in these matters may be safely entrusted to select materials and methods and to conduct himself in the presence of young people so as to stimulate and assist them in such matters.

In our examination of this area we must see that the task of choosing materials and methods is by no means easy. No process of "sugar-coating" will suffice, because such methods will be entirely unacceptable to the young people. They have real questions and real problems and will seek help from their teachers and from the school until they get that help or until they learn the search is in vain. One sees at once in this illustration the need for information about radiation, kinetics, chemical change, selected not for the study of radiation, kinetics, and chemical change as such but from these areas of knowledge to help young people deal with their problems and interests.

In a discussion of materials for teaching something should be said about fundamentals. Perhaps the trouble with science teachers and with others is that they feel they must "teach the fundamentals." If they do, their feeling is based on assumptions, the validity of which should be examined. These teachers should be reminded that, considered in the abstract, there are no fundamentals for high school students. A thing cannot be defined as fundamental unless it is *fundamental to something*. As used originally by teachers of physics or of chemistry *fundamental* meant, in a loose way, the body of knowledge necessary to further study in that science. But as teaching has come to be looked upon as a service guided by the needs of young people this meaning is no longer applicable. The term *fundamental* is now a con-

fusing one in education, and our difficulty would probably be reduced and our services improved if it could be abandoned. In this illustration we shall select materials and methods and direct our efforts toward achieving a scientific view of the world.

Obviously, desirable behavior of young people requires much more than knowledge and insight. In the selection of materials and methods other affecters of behavior must be considered. In this illustration we see clearly the need for ability to use critical methods of thinking. Charlatanry is much in evidence and, for protection from deceit, it is often essential to know what is fact and what is fraud. In seeking the answers to their questions young people will practice using theories in the situations to which the theories refer; they will learn to recognize the conditions which have to be fulfilled before valid scientific generalizations may be made; they will learn to give attention to basic, methodological problems of classification, measurement, statistics, and the like; and they will practice precise formation and communication of principles.

How may we evaluate our successes and discover our failures? A teacher must remember that successes and failures in his classes are his own. He is charged with responsibility to serve young people. If he fails he may not blame "the dumb kids." He has successes and failures as he discharges his responsibilities and will improve in his work as he studies these.

What will he look for in this illustration as evidences of successes and failures? First, he will think of knowledge and insight into the nature of the physical universe. Through these he will expect the students to gain in ability to see planets, moons, comets, meteors, and stars in the relationships which modern science supports as true. He will think of ability in critical thinking and examine his students to see whether they have gained in ability to differentiate fact and fancy, to formulate and use theories in situations to which they refer, to state facts and principles precisely, to appreciate the use of measurement, units, statistics, and the like. And he will be interested to see whether or not these abilities are actually made a part of their lives. May they be detected in overt, non-verbal behavior? The teacher may be sure that experiences such as are suggested will result in changes in attitudes and he will want to know how to describe these changes. Will the attitudes developed during their contacts with him help the students to take their places as useful members of society? Will their achievements help them to resist

the charlatanry and quackery of astrologers, of religious pretenders, of unscrupulous advertisers, ruthless politicians, and others who, for private gain or privilege, play on the ignorance and misconceptions of people with intent to deceive them.

This brief reference to evaluation in the area of world-view may be sufficient to suggest to teachers some ways in which they may become more intelligently critical of their own successes and failures.

Other illustrations may be cited to show how shortcomings may be remedied. Consider one in which the students were confronted with a practical problem and note how they learned about the importance of resources, the part science is playing in the world, some major problems confronting society, practice in scientific method, and so forth.

The students in a rural community were faced with the problem of getting electricity. The science class assumed this responsibility, investigated the cost of buying power from the nearest utility, examined and discarded an old "Delco plant," and finally constructed a twenty-four-foot overshot water wheel. The materials of construction, including a 2-kilowatt generator, had to be acquired at the least possible expense. The flow of a small stream had to be measured carefully in terms of seasonal changes. The stream had to be diverted and a flume had to be built to obtain the necessary fall. Aside from one local mountaineer, who helped in some of the carpentry, the entire project was carried out by the class and their teacher. As subsequent groups of students came and left, the hydroelectric plant continued to serve as rich instructional material. Its operation and maintenance provided a wide variety of instructional activities. In addition, there was wiring to be done in the houses, a set of batteries that had to be kept charged, and so on.

The activities in "control of energy" in this school were not confined to the problem of getting electricity. Automobiles belonging to the school needed care and maintenance. The water system, sewage disposal system, and heating system, each received considerable attention.

In Montana a teacher of physical science decided that one of the not infrequent dust storms when everyone in the community is forced to "eat dust, breathe dust, think and talk about dust" might provide a good opening for discussion of where the dust comes from, what it means in loss of soil, what deforestation and overgrazing have done, how changes in agricultural practice may reverse the destructive processes now at work. The community is a farming one, made up largely of "old settlers" who have kept their farms through "thick and thin," impoverishing themselves and their soil in the process. Most of the students will remain in the community—if the farms are still valuable enough to produce a living for them when they are grown. Sentiment is traditionally against government aid, but there is a beginning of appreciation of what soil conservation can mean. Understanding and appreciation, on a non-political basis, of what applications of modern knowledge can mean in improving living will undoubtedly spread through the community. The teacher expects, by showing "The River" and following the lines of study suggested by it, to build understanding of the interdependence of the whole Mississippi Valley and even more widely scattered communities over the face of the earth.

A teacher of chemistry is employed in a suburb of Chicago which has no sustaining industries. The students come from the homes of professional people, research workers, and tradesmen. Some are planning on scientific careers in college; some are planning to take college courses outside of the science field; some are planning to get jobs as soon as they graduate from high school; some have no outlook on life beyond the immediate present. The midwest area is sometimes referred to as the bread basket of the world. Chicago has grown to meet the problems of distribution of agricultural products and to meet the problem of supplying agricultural areas with machinery, clothing, and processed goods. Chicago and its suburbs are dependent on the farm land of the Middle West for their prosperity, and the people of this community will earn their livelihood through industries which depend for their products on the soil.

During the spring term a problem in soils and soil erosion was studied with an emphasis on conservation. This coming spring the relationships which exist between man and his environment will be stressed. Food, water, and air are accepted as necessities, but more emphasis will be given to the interrelationships which exist among them. Man's dependence on the fertility of the soil will be brought out in a study of foods. Activities in the chemical testing of soils, the examination of different types of soils, a survey (biological and physical) of the area in the immediate vicinity of the school and city, the growing of plants in nutrient solutions in the laboratory, and moving pictures such as "The River" and "The Plow that Broke the Plains" will not only be of interest to the students but, it is hoped, will result in a functional attitude toward conservation of our soil and mineral resources.

A senior high school teacher in Detroit is planning a study of the automobile as a means of teaching concepts of matter and energy. This is a very live subject to Detroiters because they are both producers and consumers of automobiles. Almost every family has a car and many of the students have cars of their own.

Here is one of the plans in which the breaking down of subject matter lines is interesting. While attention will be directed to the principles of mechanics and heat, the meaning of automobiles for human beings throws open the area of life and environment. The question of fuel supply leads to a study of conservation of petroleum, and from that to the social and economic problems of what high-priced fuel might mean to the automobile and to people living in Detroit.

The difficulties faced by young people and the problems that arise in the community may seem particularly troublesome to teachers, for they often raise issues that are in sharp conflict with the cultural mores and traditional practices. These difficulties are in evidence in the illustrations just given. If teachers themselves are lacking in knowledge and ease about the nature of the physical universe and their place in it, they will find it very difficult to inform their students on these things and to set them at ease. If the teachers are incompetent in matters of community welfare, they can hardly help their students in these matters. The solution is admittedly difficult, but these problems must be resolutely faced if teachers trained in science are to take a forward step in improving their services to young people.

It will be a forward step in improving our services to young people when we talk less about teaching the special divisions of science, physics, for example, as such and more about the responsibilities of the teacher, trained as a specialist in science, to the students and to the community. As teachers do this they will be giving more attention to their own education as persons and as citizens in communities and much less to petty technique in teaching and very much less to discussion of whether or not this or that author's statement of the principle of falling bodies is accurate.

Are these suggested reforms too much to work for? The changes called for seem to suggest pretty clearly the kinds of service the public is now demanding for its children. Teachers trained in the special fields of science have been slow to cooperate in educational reforms, and the schools have been forced to carry on without assistance from them. The job will be done better and there will undoubtedly be more places in the schools for teachers trained in science if these teachers will carry their part of the load.

NEW CONSTRUCTION AT SPENCER LENS

In order to provide facilities for the production of optical instruments and optical parts required by the National Defense Program, Spencer Lens Company, Scientific Instrument Division of American Optical Company, has let a contract to The Gillmore-Carmichael-Olson Co. for the construction of additional buildings at our Eggert Road site.

One unit of approximately the same size as the present Mechanical Parts Plant, completed last summer, will house certain prism and lens manufacture. A connecting unit two and three stories high will be utilized for the assembly of special contract work. A third unit will provide expansion for the mechanical parts operations.

The new buildings will be of the same general type of construction as the unit completed last year, and will involve the latest developments in heating, lighting, plant layout, flexibility for expansion and changes, and working conditions and facilities contributing to the welfare of our employees. Approximately 130,000 square feet of additional floor space will become available through this new construction.

Orders for machinery and equipment have been placed, and it is planned to have the new unit in operation not later than February 1, 1941.

Approximately one million and a quarter dollars will be expended in carrying through our current program. The growing demand by educational institutions and industry for the regular products of the company, such as microscopes, microtomes, projectors and other scientific optical instruments has taxed our production facilities in spite of our expansion last year. The new demands upon the optical industry, as one of the key factors in the Defense Program, necessitate our promptly putting ourselves in position to meet the requirements of the present national situation.

THE EFFECT OF CORRELATION AND FUSION ON GEOMETRY INSTRUCTION

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Among the multitude of ideas and endless variety of concepts that constitute a course of study, there are unifying principles about which the important materials of the course are grouped. As the cellular organism in biology and the electron theory in physics serve as unifying elements in their respective fields, geometry may be utilized in integrating mathematical education.[1]

> . . . Of the many vices characteristic of much Mathematical Education, not the least is the separation of the science into a number of almost watertight compartments—Arithmetic, Algebra, Euclid, Practical Geometry, &c. Yet the science is a true unity and should be developed from the beginning, and Geometry is the unifying fluid that runs through the whole.[2]

Since the beginning of the present century there has been a strong movement to bring about a correlation of related subjects in the curriculum. However, the practice of applying mathematical techniques to other fields of thought is not entirely one of the present century. Thales, who applied geometry to astronomy; Pythagoras, who combined arithmetic with geometry; and Euclid, who included plane geometry, solid geometry, algebra, and arithmetic in his *Elements*, may all be cited as proponents of fused mathematics. Nevertheless, science is found to be divorced from geometry in the early universities. Also in the early secondary schools of prominent European countries, with the single exception of England, "geometry was taught in some degree in connection with surveying and astronomy, but in the nineteenth century, with its specializing tendencies, the teaching of the subject became practically independent of any such association."[3] Thus by the latter part of the nineteenth century, the idea of correlation played an inactive part in shaping the curriculums. About this time Edward Olney of the University of Michigan attempted to revive the concept by publishing a geometry in which he made an effort to correlate the various

[1] J. S. Georges, "Functional Relations and Mathematical Training," SCHOOL SCIENCE AND MATHEMATICS, XXVI (1926), 691.

[2] Benchara Branford, *A Study of Mathematical Education* (London: Oxford University Press, 1924), p. 123.

[3] A. W. Stamper, *A History of the Teaching of Elementary Geometry*, Contributions to Education No. 23 (New York: Teachers College, Columbia University, 1909), p. 136.

topics of mathematics and to introduce applications to everyday life.[4]

John Perry, in his famous Glasgow address of 1901, emphasized the opportunities for building interrelationships between the various branches of arithmetic, algebra, geometry, and trigonometry. This idea was placed before the educators of America in 1902 by E. H. Moore who advocated the unification of pure and applied mathematics and the correlation of the different subjects of the curriculum.[5]

One of the first efforts in the United States toward a unified course in algebra and geometry was made by Edith Long in a high school at Lincoln, Nebraska, in 1902.[6] This attempt at correlation was reported successful after a two-year trial. Another experimental course in correlated mathematics, which was probably a direct result of Moore's address, was conducted under the direction of G. W. Myers at the University of Chicago. Myers published (1909–1910) two textbooks embodying the results of several years' experimentation in his teaching of correlated or fused mathematics. One of these books, *Second Year Mathematics For Secondary Schools*, is considered one of the earliest "modern" textbooks to fuse algebra and geometry. However, it has been criticized on the basis of forced fusion.[7] In spite of this criticism it has helped to promote correlation of mathematical subjects. Two years after the publication of this book the movement had made sufficient progress to call forth the endorsement of the Committee of Fifteen.[8]

Myers was followed in his work on correlation by E. R. Breslich who continued the experimental part of the program which led to a well established course. Breslich has since become recognized as one of the outstanding proponents of correlated mathematics in this country. Outcomes of his scientific investigations have been of much interest to educators. Some conclusions arrived at from his experiments were:

. . . failures were reduced until in 1920 they were less than the percentage of failures throughout the school as a whole. Withdrawals during the semester decreased, and the number of pupils electing third and fourth

[4] *Elements of Geometry* (New York: Sheldon and Company, 1871).

[5] "On the Foundations of Mathematics," *First Yearbook of the National Council of Teachers of Mathematics* (New York: Bureau of Publications, Teachers College, Columbia University, 1926), p. 47.

[6] H. B. McDonough, "Development of Mathematics in Secondary Schools of the United States" (Unpublished M. A. Thesis, George Peabody College for Teachers, 1932), p. 143.

[7] J. Shibli, *Recent Developments in the Teaching of Geometry* (State College, Pennsylvania: J. Shibli, Publisher, 1932), p. 180.

[8] National Education Association, *Final Report of the National Committee of Fifteen on Geometry Syllabus* (Chicago: The University of Chicago Press, 1913), pp. 28–30.

mathematics increased. Students who later took college mathematics at the University of Chicago made an average number of grade points which was above-average work in other subjects. Of those who went to other colleges, over half did better in mathematics than in other subjects.[9]

He further argues that a representative high-school class in correlated mathematics will cover in three years the work which in separate courses is usually given in one and one-half years of algebra, one and one-half years of geometry, and one-half year of trigonometry.[10]

After the publication of the report of the National Committee on Mathematical Requirements, which promoted the coordination of subject matter in mathematics, important progress was made. Influence, exerted by the fusion idea, was evidenced in the appearance of textbooks treating the combined or general mathematics; plane geometry texts including more and more algebraic applications, numerical trigonometry, and some applications to solid geometry; and the algebra texts including intuitive geometry as well as numerical trigonometry.

From the standpoint of education in general as well as from the standpoint of mathematical instruction, Breslich points out the need for correlation of various mathematical subjects. He insists that better training will be obtained from the study of mathematics than from the successive study of arithmetic first, then algebra, and then geometry.[11]

At a meeting in Cambridge, Massachusetts, on March 10, 1934, the Association of Teachers of Mathematics in New England passed the following recommendation concerning mathematics: "A full year course consisting of trigonometry, solid geometry, and advanced algebra is to be preferred to the present practice of offering half-year courses in only two of these three subjects.[12]

Not only have there been attempts to integrate mathematics within its own boundaries but also to unify the whole program of instruction. History shows that the union of mathematics and science has helped to develop both. Courses in general science which combine mathematics, physics, and chemistry have been well established. More progress has been made in the

[9] H. E. Benze, "A Summary of Some Scientific Investigations of the Teaching of High School Mathematics," *Eighth Yearbook of the National Council of Teachers of Mathematics* (New York: Columbia University, 1933) p. 24.

[10] E. R. Breslich, "Correlation of Mathematical Subjects," SCHOOL SCIENCE AND MATHEMATICS, XX (1920), 127.

[11] E. R. Breslich, "Secondary School Mathematics and the Changing Curriculum," *The Mathematics Teacher*, XXVI (1933), 327–349

[12] Aaron Freilich "There is Fusion in the Air," *The Mathematics Teacher*, XXVIII (1935), 46.

elementary schools along the lines of integration than in the high schools. Along with seeming success in the integrated work of the lower grades, there has developed a difference between the elementary school philosophy of education and that prevailing at the high school level. In expressing needs of the high schools of New York City, Clark has stated:

> There is need of an integrated curriculum not only in subjects begun in the junior high school and continued in the senior high school, such as foreign language, mathematics, and commercial studies, but also within any particular school department or subject class. . . . Opportunities of such correlation or integration are many in the traditional "humanities"—the social studies, foreign languages and English. It is only through integration in the fullest sense of the word—educational philosophy, guidance, curriculum, methods—that we can build up the proper organization of material and of learning procedures that will satisfy the individual pupil's capacity and needs.[13]

By the close of 1934 the Committee for the New York Association of Chairmen of Mathematics Departments had compiled a syllabus correlating algebra and plane geometry for the ninth and tenth years.

Advantages claimed for fusion mathematics were:

1. It is possible to make the function concept the unifying and underlying idea of all mathematics instruction.
2. There is greater exposure to the topics in the several subjects that are fused.
3. Each subject is strengthened by the other, when taken together.
4. There is a wider field for application.
5. It gives more power to the learner since he has the liberty to use either one or all of the subjects to solve this problem.
6. It leads to more thorough understanding and better retention.
7. It will result in greater numbers benefiting by the study of mathematics since pupils who want more than two years of mathematics will have to take another full year instead of a half year course as at present.
8. It reduces the number of Regents and College Entrance Board examinations.
9. It eliminates much of the review and repetition which are necessary in the old water-right compartment division of subject matter..
10. European experience with fusion on a large scale has been entirely satisfactory.[14]

One recent text embodies the idea of *functional relation* as the one great idea best adapted to unify the courses in mathematics.[15] The material presented in this text is the result of several years of experimenting in the classroom with the purpose of making the mathematics of the tenth year more comprehensive,

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[13] W. A. Clark, "What Does the State Survey Report Mean to Us?" *High Points*, XVI (1934), 9.
[14] Freilich, *op. cit.*, pp. 46–47.
[15] J. A. Swenson, *Integrated Mathematics with Special Application to Geometry* (Ann Arbor, Michigan: Edwards Brothers, Inc., 1936).

dynamic, and functional in character. Special application is made to geometry: however, algebra, analytics and trigonometry also play important roles throughout the book.

Closely related to, or in connection with, the development of correlated mathematics is the movement for teaching solid geometry in connection with plane geometry. At the beginning of the nineteenth century, Lacroix, a French mathematician, pointed out the analogies between certain theorems of plane and solid geometry and suggested the possibility of combining instruction in certain cases. With reference to the correspondence between plane and solid geometry, Lacroix says: "Many lines and figures traced on a plane are only particular cases of lines, planes and solids considered in space; and it is indispensable, wherever possible, to teach in close relation those parts of plane and solid geometry that admit of analogous treatment."[16]

Gergonne (c. 1825) raised the question of whether it was natural to separate the teaching of solid geometry from that of plane. Mahistre in 1840 pointed out the advantages of employing the principle of analogy, and Valet in 1866 published a pamphlet on the reforms of teaching elementary geometry in which he carried out the idea of fusing plane and solid geometry.

A work which has claimed the attention of more recent French teachers is that by Charles Meray, called "Nouveaux éléments de géométrie." In this development, Meray sets individual propositions in solid geometry over against the corresponding ones in plane geometry, treating in close connection the properties of the straight lines and planes and the theorems on their intersection, perpendicularity of straight lines and of planes, and comparison of plane and dihedral angles. Meray's method received official recognition in France and was adopted in a considerable number of French schools.[17]

In America a proposal was made to the College Entrance Examination Board that it should modify its requirements so as to bring about the more extensive introduction of courses which would include an appreciable amount of solid geometry in the first year of geometry in place of a part of the plane geometry already taught. Consequently, at the Board's request, the Mathematical Association of America and the National Council of Teachers of Mathematics appointed a joint committee to study the feasibility of modifying requirements.[18] In 1930 a

[16] Stamper, *op. cit.*, p. 84.

[17] *Ibid.*, pp. 110–111.

[18] Dunham Jackson, "College Entrance Requirements in Geometry," *The Mathematics Teacher*, XXII (1929), 487.

new committee was named to make a second report which, it was hoped, would be of a more definite nature than that of the first.[19]

The Fifth Yearbook of the National Council of Teachers of Mathematics (1930) was intended to supplement and assist the committee in studying the feasibility of a combined one-year course in plane and solid geometry. It was not intended to be a report of this committee but was intended mainly to stimulate discussion among teachers of mathematics throughout the country and to clarify the situation for the committee as much as possible. Gertrude E. Allen, who experimented with the distribution of geometry material, recognized in this reorganization of subject matter an open field for investigation.[20]

Interest in the question of geometry was outstanding at the meeting of the National Council of Teachers of Mathematics held at Detroit in February, 1931. "The Relation of Mathematics to Modern Thought" was the general theme of the meeting. The importance of reorganizing geometry was set forth by Professor Beatley in his address, "Revision of Instruction in Geometry in Secondary Schools," and Austin gave the reports of the committees which were investigating the status and methods of teaching geometry with special reference to combining plane and solid geometry. In this report, Austin presented definite opinions from persons who have had experience with the project and opinions from some who may not have tried the combined course.[21] C. A. Stone of the University High School of Chicago reported the results secured by a questionnaire sent to about 150 teachers. One hundred four favored instruction in solid geometry in high school; six opposed. Twenty-seven favored a one-year course in plane and solid geometry; twenty-eight opposed it. Twenty-seven favored a fused course; eighteen, a tandem or parallel organization. The conclusions of the report given by this second committee on geometry follow:

1. Although believing that it would be valuable for all students to have a knowledge of three dimensional geometry, the committee is not ready to recommend the adoption of a one-year course in plane and solid geometry for all tenth year pupils.
2. Practically all the people who have experimented with this problem

[19] Charles M. Austin, "Report of the Second Committee on Geometry," *The Mathematics Teacher*, XXIV (1931), 370–394.

[20] Gertrude E. Allen, "An Experiment of Material for High School Geometry," *Fifth Yearbook of the National Council of Teachers of Mathematics* (New York: Bureau of Publications, Teachers College, Columbia University, 1930), pp. 67–85.

[21] Austin, *op. cit.*, p. 371.

and who favor the combined course agree that the work in solid geometry should be done intuitively.

3. It does not seem possible to do this combined course in the tenth year unless it is preceded by some intuitive geometry of a very high grade, both plane and solid, in the Junior High School.

4. At present the experimental basis is not strong enough to warrant the institution of the one-year course. Although tried in several places the course has not been continued.

5. If by experimentation a satisfactory one-year course in solid geometry can be arranged, it should be followed by a third semester course containing the more difficult parts of both plane and solid. This course should be taken only by those who desire a complete knowledge of geometry and a better preparation for their advanced work.

6. Under present school conditions about the best thing teachers can do is to introduce into our plane geometry course the analogous solid geometry. Thus, when studying areas in Book IV, the lateral and total areas of the prism, pyramid and frustum of pyramid could easily be deduced. Then in Book V, might follow a study of cylinder and cone.

7. Other excursions into solid geometry might be made when studying angles, parallels, circles and loci.

8. Even this work is not advised without careful preparation by the teacher, both as to material and to method.[22]

Lide's report of 1931, a part of the National Survey of Secondary Education, showed a very definite criticism of the traditional content of plane geometry.[23] In February 1932, at the meeting of the National Council in Washington, the following motion was passed without dissenting vote:

> The National Council of Teachers of Mathematics reaffirm their interest in the question of geometry as expressed at the annual meeting in Detroit, and hope that the Board of Directors will find it possible to initiate and carry forward a study of the whole question of geometry in our schools.[24]

Betz, who was at that time president of the Council, was empowered to appoint a Committee on Geometry. He selected six members of the National Council for immediate service, intending to enlarge the committee to include a wider range of interest and opinion. By October, 1933, the committee had been enlarged to twenty-six members and had assembled as many as possible of the suggestions which had been made during the twentieth century concerning the teaching of geometry, both intuitive and demonstrative. These suggestions were gleaned from articles on geometry in periodicals, reports, books on method (domestic and foreign), dissertations, and classroom texts (domestic and foreign). A list showing the scope of ma-

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[22] *Ibid.*, p. 378.

[23] E. S. Lide, *Instruction in Mathematics*, National Survey of Secondary Education. Washington: United States Printing Office, 1933.

[24] Ralph Beatley, "Preliminary Report of the Committee on Geometry," *The Mathematics Teacher*, XXV (1932), 427.

terial examined is given in "Second Report of the Committee on Geometry."[25] This quest for the novel and the foreign indicates that there was no bias on the part of the committee but there was a desire to encourage all suggestions that seem to have merit. The ideas obtained from the synopses were studied and a questionnaire based on these ideas was sent to each member of the committee and to teachers of mathematics from Maine, Massachusetts, Ohio, Illinois, Minnesota, Kansas, and Colorado. Thus the replies represent not only the opinions of the members of the committee but the opinions of 101 teachers. The major ideas on which the questionnaire is based are listed in the third report of the committee on geometry.[26] The general tenor of the replies may be summarized as follows:

1. It was generally agreed that the important facts of geometry can be mastered below the tenth grade.
2. There was a definite preference to concentrate demonstrative geometry in a single grade in the senior high school.
3. Almost universal support was given to the proposal that the pupil begin demonstrative geometry by attempting to solve originals instead of book theorems and that emphasis be placed on analyses before synthetic proofs.
4. A large majority favored the free use of algebra in the demonstrative geometry.
5. There was almost unanimous agreement that goemetry can be taught so that it will develop the power to reason logically more readily than other school subjects.
6. Occasional reference to solid geometry in the course of plane geometry was favored by nearly everyone.

More recently, the Joint Commission on the Place of Mathematics in Secondary Education has continued to encourage the attempts of the College Entrance Examination Board and other bodies to get away from a too rigid compartmental plan of teaching mathematics.[27] Although suggested outlines for a one-year course in plane and solid geometry have appeared in print, the reports received from teachers who have experimented with this reorganization have not been encouraging. It is possible that these failures are due to the absence of a well planned course

[25] Ralph Beatley, "Second Report of the Committee on Geometry," *The Mathematics Teacher*, XXVI (1933), 366–371.

[26] Ralph Beatley, "Third Report of the Committee on Geometry," *The Mathematics Teacher*, XXVIII (1935), 329–379.

[27] The Joint Commission of the Mathematical Association of America, Inc., and the National Council of Teachers of Mathematics, *The Place of Mathematics in Secondary Education*, Preliminary Report (Ann Arbor, Michigan: Edwards Brothers, Inc., 1938).

treating plane and solid geometry psychologically. A mere compilation of geometric propositions and exercises, which have no relation to the pupil's environment, does not suffice to meet educational needs. Therefore, genuine applied problems, which are actually encountered in the activities of boys and girls, in ordinary everyday life, in the sciences and arts, and in the various practical industrial vocations, have been included in geometry texts. Emphasis is now being placed on a minimum list of theorems. It is generally accepted that to teach with a few fundamental and important ideas and to show how they may be applied, is better than to attempt many theorems.[28] Consequently, a more meaningful treatment of the really "great basal propositions of geometry" is made possible.

Recent experiments have substantiated the desirability of including non-mathematical material to promote transfer of training in geometry courses. Fawcett, who conducted a successful experiment at Ohio State University, included such material in a high school course known as *The Nature of Proof*.[29] The course was taught with the following purposes:

1. To train the pupils in critical and reflective thinking.
2. To train the pupils in clear and unambiguous expression.
3. To teach for transfer of training in habits of deductive thinking.
4. To develop objective attitudes in dealing with non-mathematical problems.

Theories in educational psychology have been influential in promoting the practice of correlating geometry with other school subjects as well as with the mathematical subjects. Instead of emphasizing actual content it is considered more profitable to concentrate on developing powerful methods of thought. Geometry illustrates clear thinking. It shows how thinking must be done if the process is to be sound, dependable and rigorous. Although many useful facts and ideas concerning size, shape, and position are demonstrated by geometry, more important is the development of abilities to do clear thinking.

[28] H. C. Christofferson, "Trends for Improving Instruction in Mathematics," *The Mathematics Teacher*, XXX (1937), 19.

[29] H. P. Fawcett, *The Nature of Proof*, Thirteenth Yearbook of the National Council of Teachers of Mathematics (New York: Bureau of Publications, Teachers College, Columbia University, 1938).

Use the membership blank opposite page 800 to get a new member for the Central Association of Science and Mathematics Teachers.

VALENCE BLOCKS VISUALIZE HIGH SCHOOL CHEMISTRY FUNDAMENTALS

A. H. Bryan
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The solution of many difficult chemistry fundamentals by virtue of the recently patented Bryan's Valence Blocks now in course of manufacture is about to enter the chemistry class room and laboratory.

The beginning chemistry student simply fits the blocks together reading off equations, formulae, and molecular weights, ionization, valence, laws of acids, bases and salts, strength of reactions, etc.

These visualized aids were demonstrated at the 1939 Convention of American Chemical Society to chemistry teachers all

over the country. The blocks number some 200 geometric figures, each one representing some element or radical frequently used in general inorganic chemistry, consisting of circles, squares, triangles, rectangles and ovals. Each has a varying number of arms corresponding to the valence. Positive ion arms are pointed and negative ion arms are slotted. The blocks are labeled with the chemical symbol, name, atomic or molecular weight. They are colored various shades of red and blue indicating litmus reaction, metal or non-metal.

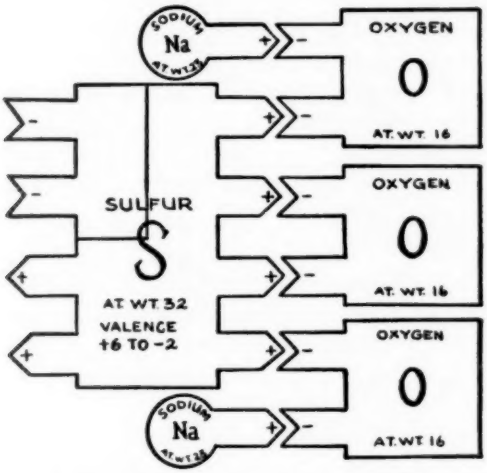
To construct formulae the student simply fits any blocks together and reads off the results so obtained. To make the formula for nitric acid the student picks out the nitrate block NO_3 and connects it with hydrogen H block to form HNO_3. The colors are deep shades representing a stable compound. The molecular weight is obtained by adding together the weights indicated on the blocks.

To construct the formula for calcium sulfate the student picks out the Ca two-armed blue block and the red two-armed SO_4 sulfate block and note that they fit together to form $CaSO_4$.

To form carbonic acid, however, two hydrogen blocks are needed to satisfy the carbonate radical which has two left arms indicating a negative valence of 2, thus H_2CO_3 is the resultant compound.

Similarily, equations may be visualized accurately by constructing the necessary formula as before and placing a plus sign between each; e.g. HNO_3 plus NaOH. Then an arrow follows. Next the H is carried over to unite with the OH block forming HOH and the Na block is united with NO_3 block completing the equation $NaNO_3$ plus HOH.

The diamonds represent elements with more than one positive valence forming "ous" and "ic" compounds such as Fe, Cu, and Hg. To form mercurous chloride the Hg block is fitted to



the negative chlorine block to form HgCl. To form mercuric chloride two Cl blocks are connected to the Hg block forming $HgCl_2$.

The polyvalent elements N, C, and S, with both negative and positive valences, are represented by rectangles with colors red and blue, and both negative and positive arms. To form carbon dioxide merely fit two two-armed oxygen blocks to the four positive arms on the carbon block to form CO_3. The negative arms do not enter into this equation. Literally a thousand and one chemical reactions and combinations are possible by simply fitting red and blue blocks together.

The blocks may be used to play an educational chemistry game similar to dominoes with any number of students or play-

ers participating. The complexity of the game will vary with the players' mastery of the science.

Large sets might be built for blackboard demonstration by teachers, and braille labeled blocks have been used by blind science students. The Porter Chemical Company of Hagerstown, Maryland is sponsoring their manufacture and production.

THE QUADRATIC EQUATION

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When reviewing old matters it is often well to "see things in a different light." For such a purpose the following outline on the quadratic equation is offered.

We make no assumption other than $a \neq 0$ in regard to the nature of the numbers a, b, c, x of the equation

$$ax^2+bx+c=0. \tag{1}$$

Hence we may take

$$m=-\frac{b}{a}, \qquad n=\frac{c}{a}, \tag{2}$$

so that

$$a(x^2-mx+n)=0.$$

Consequently, a root of (1) satisfies the equation

$$x^2-mx+n=0 \tag{3}$$

and conversely.

The matters we wish to consider are:

(I) If r is a root of equation (1), then $m-r$ is a root.

(II) The product of the roots r and $m-r$ of (1) is n.

(III) According as the roots r and $m-r$ of (1) are the same or different, $b^2=4ac$ or $b^2 \neq 4ac$.

(IV) The roots r and $m-r$ of (1) are the same or different according as $b^2=4ac$ or $b^2 \neq 4ac$.

(V) Equation (1) cannot have more than two different roots.

(VI) The roots of (1) are $(-b \pm \sqrt{b^2-4ac})/2a$.

(VII) If $r+s=m$ and $rs=n$, then r and s are the roots of (1).

(VIII) If r is a root of (1), then $z-r$ is a factor of az^2+bz+c.

(IX) If $z-r$ is a factor of az^2+bz+c, then r is a root of (1).

The proofs of the above theorems follow.

(I) Since r is a root of (1), $r^2-mr+n=0$.
Add the identity $m^2-2mr-m^2+2mr=0$.
Then $(m-r)^2-m(m-r)+n=0$.
Therefore $m-r$ is a root of (1).

(II) Since r is a root of (1), $r^2-mr+n=0$.
From this we find $r(m-r)=n$.

(III) If $r=m-r$, then $r=(1/2)m$. Substituting $(1/2)m$ for r in $r^2-mr+n=0$ we find $m^2=4n$. This, with (2), gives $b^2=4ac$.
If $r\neq m-r$, then $r\neq(1/2)m$. Take $r=(1/2)m+k$, so that $k\neq 0$. Then $m-r=(1/2)m-k$. By (II), $(1/4)m^2-k^2=n$. Hence $m^2\neq 4n$, and $b^2\neq 4ac$.

(IV) Since r is a root of (1), $r^2-mr+n=0$
so that $4r^2-4mr=-4n$.
From $b^2\neq 4ac$ and (2) $m^2\neq 4n$.
Adding $(2r-m)^2\neq 0$
so that $2r-m\neq 0$.
Hence $r\neq m-r$.
If $m^2=4n$, inequality becomes equality.

(V) Let r and s be two different roots. By (I), $m-r$ and $m-s$ are roots. To show that $r=m-s$ will suffice. By (II), $r(m-r)=n$, $s(m-s)=n$.
Hence $mr-r^2=ms-s^2$
or $(r^2-s^2)-m(r-s)=0$.
Since $r\neq s$, $r-s\neq 0$. Dividing by $r-s$, $r+s-m=0$,
so that $r=m-s$.

(VI) Take k so that $r=(1/2)m+k$. Then $m-r=(1/2)m-k$.
By (II) $(1/4)m^2-k^2=n$.
Hence $k=\pm\sqrt{(1/4)m^2-n}$,
and
$$r=(1/2)(m\pm\sqrt{m^2-4n}),\quad m-r=(1/2)(m\mp\sqrt{m^2-4n}).$$
Then, by (2), the roots are $(-b\pm\sqrt{b^2-4ac})/2a$.

(VII) If x denotes either r or s, then, since $r+s=m$, $m-x$ denotes s or r respectively. Since $rs=n$, $x(m-x)=n$,
that is, $x^2-mx+n=0$.

(VIII) Since r is a root of (1), $ar^2+br+c=0$.
Then
$$\begin{aligned} az^2+bz+c &= az^2+bz+c-(ar^2+br+c) \\ &= a(z^2-r^2)+b(z-r) \end{aligned}$$

$$=(z-r)(az+ar+b).$$

(IX) Divide az^2+bz+c by $z-r$. Thus:

$$\begin{array}{r} z-r)\overline{az^2+bz+c}(az+ar+b \\ \underline{az^2-arz} \\ (ar+b)z+c \\ \underline{(ar+b)z-ar^2-br} \\ ar^2+br+c. \end{array}$$

Since $z-r$ is a factor, the number r must be such that

$$ar^2+br+c=0.$$

Therefore r is a root of (1).

BOTANICAL EXPEDITION TO SPEND SEVEN MONTHS IN GUATEMALA

A botanical expedition into the forests of Guatemala will be conducted during the coming seven months by Paul C. Standley, curator of the herbarium of the Field Museum of Natural History. The expedition will continue the work of a previous one by Mr. Standley in 1938–39, and an expedition by Julian A. Steyermark, assistant curator of the herbarium, earlier this year.

The ultimate purpose of all three expeditions is the building up of a complete knowledge of the plant life of Guatemala, which is botanically one of the richest and most varied of all tropical areas of its size. Eventually an illustrated book on Guatemalan flora will be published.

PLANTS SHOWN TO ACQUIRE IMMUNITY TO DISEASE

Plants do acquire immunity to disease, and in much the same way as animals do, is the conclusion reached by Dr. James M. Wallace, of the U. S. Department of Agriculture.

Testing the destructive sugar-beet curly-top disease on tobacco, Dr. Wallace found that severely affected plants recovered, or at least showed very few evidences of the malady. At the same time, he discovered that there seemed to be developed by the plant an unnamed something which caused the disease to be held in check. The disease was still in the plants, Dr. Wallace explained, for healthy tobacco plants could be infected from the recovered ones.

Dr. Wallace grafted healthy scions on diseased stocks, and diseased scions on healthy stocks, and found that the healthy portion became diseased, but mildly, depending on the length of time the disease-masking "something" had had to develop.

"In short," says Dr. Wallace, "the phenomena are comparable to those known in animal diseases in cases of active immunization and the production of passive immunization by protective substances or antibodies. On the basis of the evidence obtained in these experiments, the behavior of the recovered plants is interpreted as acquired immunity and that this acquired condition results from protective substances produced by a specific relation between the tobacco plants and the curly-top virus."

THE CONTENT OF JUNIOR HIGH SCHOOL SCIENCE

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(*Concluded from October issue*)

TABLE V. TOPICS FREQUENTLY USED IN EIGHTH GRADE TEXTS

Descriptive Title	I	II	III	IV
Topics Appearing in Four Texts				
1. Conditions of air most favorable to man	C	P	P	P
2. Causes of the seasons of the year	I	O	O	O
Topics Appearing in Three Texts				
1. Sources of water	D	D		D
2. Water in our homes	D	D		D
3. Control and use of water in the home	D	D		D
4. City water supplies	D	D		D
5. Water in the removal of wastes	D	D		D
6. Water's action on the earth's surface	J		J	D
7. The sun		O	O	O
8. The moon and moons		O	O	O
9. The planets and planetoids		O	O	O
10. Universal gravitation		O	O	O
11. Motions of the earth		O	O	O
12. Causes in the variance in length of night and day		O	O	O
13. Scientific weather signs		P	P	P
14. Wind		P	P	P
Topics Appearing in Two Texts				
1. Why do we find different things in different environments	B		S	
2. Artificial lighting	F			F
3. Electro-magnets	G			G
4. Heating effects of an electric current	G			G
5. Purpose of machines	H			H
6. How do machines make work easier	H			H
7. Telling of time	I	O		
8. Formation of mountains	J		J	
9. Methods of protecting milk, food, and water supplies	M			M
10. Harmful effects of alcohol & tobacco	M		U	
11. Need for community health	N	N		
12. Immunity from disease	N		S	
13. Stars and star groups		O		O
14. Celestial distances		O	O	
15. A developing universe		O		O
16. Adaptations to the seasons		O	S	
17. Temperature		P		P
18. Measurement of temperature		P		P
19. Causes of difference in air temperature		P		P
20. Measurement of air pressure		P		P

TABLE V. TOPICS FREQUENTLY USED IN EIGHTH GRADE TEXTS

Descriptive Title	I	II	III	IV
Topics Appearing in Two Texts				
21. Precipitation and its causes		P		P
22. Local storms		P	P	
23. General storm areas		P		P
24. Properties of water		D		D
25. Uses of water in relationship to properties		D		D
26. Water as a cleansing agent		D		D
27. Soap as an aid to cleansing		D		D
28. Preparation of soil for planting		Q		Q
29. Planning a garden		Q		Q
30. Time and method of planting		Q		Q
31. Weed control		Q		Q
32. Harmful garden insects		Q		Q
33. Plant diseases		Q		Q
34. Control of garden pests		Q		Q
35. Plant reproduction		S	S	
36. Need for vegetable garden		R		R
37. Methods of storing food		R		R
38. Conservation of food in the home		R		R
39. Operation of a refrigerator		R		R
40. Food protection in relation to health protection		R		R
41. Man's adaptations to nature		R	S	
42. Comets			O	O
43. Meteors and Meteorites			O	O
44. Effect of wind and ocean currents upon climate			P	P
45. Causes of difference in climate			P	P
46. The Weather Bureau			P	P
47. Instruments for measuring changes which effect weather			P	P
48. Cyclones and anti-cyclones			P	P
49. Tornado and hurricanes			P	P
50. Conditions which affect plant growth			S	Q
51. Origin of carbohydrates and their digestion			U	Z
52. Origins of fats and their digestion			U	Z
53. Origin of proteins and their digestion			U	Z
54. Assimilation of the food we eat			U	Z
55. Bodily function during exercise			U	Z

Table V corresponds to Table II except that it was developed from the analyses of the eighth grade texts. It should be read in the same manner; that is, Topic I, *Conditions of Air Most Favorable to Man*, was used in the development of two different units in the four texts analyzed but was used in all four texts. Reference to Table I and the lists appearing on page 7 will en-

able the reader to determine the manner in which the different topics are used in developing the various units.

TABLE VI. TOTAL CONCEPTS. NUMBER PRESENT IN EACH EIGHTH GRADE TEXT AND PER CENT OF TOTAL IN EACH TEXT

	Total Concepts in Check Lists	Text I	Text II	Text III	Text IV
Astronomy	99	16 16.16%	69 69.69%	56 56.56%	32 32.32%
Biology	520	88 16.92%	47 9.23%	84 16.15%	51 9.81%
Chemistry	310	13 4.19%	28 9.03%	10 3.23%	19 6.13%
Geology	73	24 32.87%	5 6.85%	33 45.21%	7 9.59%
Health	350	82 23.43%	46 13.14%	43 12.28%	39 11.14%
Physics	215	44 20.46%	28 13.02%	8 3.72%	86 40%
TOTALS	1567	267 17%	223 14%	234 15%	234 15%

Perhaps the most striking thing disclosed by Table VI is the close agreement between the authors of the various texts in the total number of concepts to be included at this level. In reading this table the same procedure should be used as in Table III. That is, Text I used 16.16% of the 99 items in the astronomy check list; 16.92% of the 520 items in the biology check list; 4.19% of the 310 items in the chemistry check list, and so on. Or in comparing the relative amount of concepts of a given field, for example physics, we find that Text I used 20.46%, Text II used 13.02%, Text III used only 3.72%, and Text IV used 40%, of the 215 items usually taught in high school physics.

TABLE VII. LIST OF BASIC CONCEPTS OF EACH MAJOR SUBJECT FIELD INCLUDED IN THE MAJORITY OF THE EIGHTH GRADE TEXTS ANALYZED

Astronomy

Concepts appearing in four texts:

1. Causes of night and day
2. Inclination of the earth's axis

Concepts appearing in three texts:

1. Temperature of the sun
2. Direct and oblique rays

3. Sun as a source of energy
4. Distance the earth is from the sun
5. Motions of the earth
6. Positions of the stars
7. Stars are suns
8. Constellations
9. Celestial distances
10. Names and positions of planets
11. Orbits of planets
12. Meteors
13. Effect of moon on earth's surface
14. Eclipse (sun and moon).
15. Atmosphere on the moon
16. Cyclones
17. Low and high pressure areas
18. Unequal heating of the surface of the earth as the cause of movements of air
19. Sea and land breezes

Biology

Concepts appearing in three texts:

1. Insects are pests to man in all parts of the world.
2. The seed has within itself all the kinds of nutrients needed for the growth of the miniature plant, or embryo, except water.
3. Fungi are spore plants which have no chlorophyll and have to depend upon other plants or animals for organic food.
4. One of the most common fungi is bread mold.
5. A culture medium is a jelly-like substance used for the nourishment of bacteria.
6. Inoculation is the exposure of cultures to bacteria.
7. Plants obtain minerals from the soil materials.
8. Fertilizers are substances used to replace elements taken from the soil by plants and all other elements.

Chemistry

Concepts appearing in three texts:

1. Removal of dispersed materials from water by filtration
2. Removal of dispersed materials from water by boiling

Geology

Concepts appearing in four texts:

1. Erosion

Concepts appearing in three texts:

1. Weathering
2. Running water
3. Springs

Health

Concepts appearing in three texts:

1. Need of drinking water
2. Importance of safe water supply
3. Protection of water supply from pollution
4. Purifying and filtering city water supply
5. City's dependence on water supply
6. Food protection in general
7. Methods of preserving foods

8. Cause of food decay
9. How to prevent decay of food
10. Prevention of spread of disease by intermediate host—fly, mosquito, louse, tick, rat
11. Knowledge of typhoid

Physics

Concepts appearing in three texts:

1. Air pressure
2. Newton's law of universal gravitation
3. Conduction of heat
4. Convection
5. Radiation
6. Sources of light
7. Reflection of light
8. Transmission of light
9. Heating effects of an electric current.

Analysis of Findings for the Eighth Grade

The maximum frequency of use of any single unit was three and this occurred in the case of two different titles. Ten other unit titles were used in two texts only. Fourteen titles were used in single texts. In no case did a given unit appear in all four texts.

One hundred fifty-eight different topics appeared in the texts analyzed. Of these only two were used in all four texts. Fourteen topics were used in three texts. This might appear to be pretty well standardized, but a reference to Table V will show that these topics were distributed in different units, from which we infer that the emphasis was placed on different aspects of the topic.

Fifty-five topics were used in two texts, but here also there is little agreement as to the use of these topics, since they were employed in different units in the different books and therefore were given different emphases. in the case of topics as well as units the agreement that a given topic should be used was not consistently followed by any two or three authors. As an illustration, Unit D was present in Texts 1, 2 and 4, but Unit O, which was also used three times, was present in a different combination of the texts; that is, Text 2, 3, and 4. Where two units or two topics are involved, the spread is even greater.

In Table VI we find that there was a considerable variation in the percentage of concepts of a given field used by the different authors. An actual study of the concepts used shows that even where the percentages were roughly alike, the actual concept lists did not agree. In the totals of Table VI we find that Text I

used 17% of the total number of concepts in the check lists; Text II used 14%; Text III, 15%; and Text IV, 15%. This would seem to indicate a high degree of uniformity of opinion as to the concepts to be taught at this level. However, a comparison of the lists shows that of the number used by one text, only a very small percentage were actually used by other texts. This fact may be further established by an examination of the titles of the biology concepts used in each text. Text I uses a total of 88 concepts, while Text II uses 47. If the 47 concepts used in Text II were all contained in the 88 used in Text I, and likewise

TABLE VIII. TOPICS FREQUENTLY USED IN NINTH GRADE TEXTS

Descriptive Title	I	II	III	IV
Topics Appearing in Three Texts				
1. Measuring Electricity	K	B		K
Topics Appearing in Two Texts				
1. The community water supply		B		C
2. The use of electricity in communication	Q	F		
3. Food as fuel for the human engine		W		W
4. Conservation of our wild life	X		X	
5. How do plants and animals reproduce?	AA			AA
6. What is electricity?	K			K
7. How is electricity generated and distributed?	K			K
8. Water transportation	P	P		
9. Development of steam transportation in United States	P			P
10. Development in new plants and varieties			BB	BB
11. What is meant by the balance of nature			GG	GG

for Texts III and IV, then the total percentage figures would be more significant. That, however, is not the case, and the maximum number of different concepts of biology used in the four texts is 186 and not 88 as one might be led to believe. The only agreement among the authors seems to be that the total number of concepts which may be successfully mastered by 8th grade pupils lies within the range of 223 to 267. We must conclude that there is little uniformity in the choice of materials included in the various texts at the 8th grade level.

It must be noted that the narrow range in the number of concepts is not indicative of the manner in which these concepts are treated, as the amount of space devoted to the development of the concepts varies widely.

Table VIII is parallel to Tables II and IV except that the

content deals with the units used in a ninth grade text. Only one topic was used in three of the four series analyzed, and it was used in developing two different units. It is to be noted that a great many of the ninth grade texts were written with the idea that they might be sold for use independent of the seventh and eighth grade books. Consequently there is an effort on the part of the authors of some of the series to include all of the content recommended in various courses of study for the ninth grade.

TABLE IX. TOTAL CONCEPTS. NUMBER PRESENT IN EACH NINTH GRADE TEXT AND PER CENT OF TOTAL IN EACH TEXT

	Total Concepts in Each Check List	Text I	Text II	Text III	Text IV
Astronomy	14	11 79%	11 79%	4 28.5%	13 92.8%
Biology	520	76 14.6%	199 38.4%	114 21.9%	113 25.5%
Chemistry	310	28 9%	46 14.7%	16 5.1%	20 6.4%
Geology	73	25 34.2%	33 45.2%	9 12.3%	26 35.6%
Health	350	32 8.9%	172 49.1%	34 9.2%	50 13.3%
Physics	215	83 38.6%	108 50.2%	86 40%	102 47.4%
TOTALS	1482	255 17.2%	569 38.4%	263 17.7%	324 21.8%

A great many of the concepts are duplicated throughout the different series, but the topics listed here were developed with different combinations of the concepts and probably contained an approach that makes them distinctly different from those used by other authors. Only eleven topics are actually duplicated in two of the texts analyzed.

Table IX shows the percentage of concepts in the various subject matter fields. In this area we find the widest discrepancies in the total number of concepts included in the various series. Out of a total of 1,482 items, the range of items used extended from 255 to 569. This table corresponds in the paper to Tables III and VI and is to be read in the same way. For example, in the chemistry area 310 concepts appeared in our check

list. Text I used 28 of these, a total of 9%; Text II used 14.7%; Table III, 5.1%; and Table IV, 6.4%. The implications of the figures in this table will be discussed in the findings of the ninth grade study.

The following constitutes the most frequently occurring concepts. Only those are included which were used in three or more texts. The list of concepts appearing in one or two texts only is too long to be included in this publication.

TABLE X. LIST OF BASIC CONCEPTS OF EACH SCIENCE INCLUDED IN THE MAJORITY OF NINTH GRADE TEXTS STUDIED

Astronomy:

Concepts appearing in four texts:

1. Solar system
2. Nebulae
3. Planets
4. Milky Way—Galaxy
5. Comets

Concepts appearing in three texts:

1. Distance to the moon
2. Phase of moon
3. Eclipse of moon
4. Halley's Comet
5. Meteoric showers
6. Distance to stars
7. Number of stars visible
8. North Star
9. Constellations

Biology

Concepts appearing in four texts:

1. Man has brought about great environmental changes.
2. Flowers are the organs which indicate the attempt of the plant to reproduce its kind.
3. The parts of the flower are sepals, calyx, petals, corolla, stamen, pistils.
4. Pollination is a process of fertilization, making a flower capable of producing seed.
5. Flowers may be cross-pollinated or self-pollinated.
6. Insects are important in that they pollinate flowers.
7. Irrigation is the adding of water to soils in arid regions.
8. Alcohol decreases the efficiency of the nervous system in every way.
9. A calorie is the amount of heat required to raise the temperature of one lb. of water 4° Fahrenheit.
10. Gregory Mendel was the first man to experiment scientifically in heredity.
11. Edward Jenner performed the first vaccination.

Concepts appearing in three texts:

1. Three classes of foods used by plants are: proteins, fats, carbohydrates.
2. Cells—simplest unit of life.
3. Plants have played a large part in changing the environment.

4. Advanced civilization has caused wild life and natural resources to rapidly diminish.
5. Causes of forest destruction are careless lumbering, fire, insect enemies, fungus enemies, weather conditions, and animals.
6. Organs begin growth by cell division.
7. Most embryos are furnished with food from the egg.
8. Man is more indebted to birds than to any animal.
9. Mosquitoes carry disease germs in their blood and thereby carry them to man.
10. Malaria was found to be carried by the mosquito
11. Heredity may be defined as the transmission of physical and mental traits from parents to offspring.
12. To control insects we must conserve their natural enemies.
13. Stamens produce pollen without which seed cannot be formed.
14. Some flowers are adapted for wind pollination.
15. The plant leaf manufactures food for the whole plant.
16. Air pores of a leaf are called stomata.
17. The life processes carried on by the leaf are: photosynthesis, respiration, digestion, circulation, assimilation, and excretion.
18. The waste product of photosynthetic is oxygen.
19. Chlorophyll is the green coloring matter of the plant.
20. Photosynthetic cannot occur if the plant does not have chlorophyll.
21. Roots may be a storage place for foods.
22. Fungi are spore plants which have no chlorophyll and have to depend on other plants or animals for organic foods.
23. Pasteurization is the heating of milk to a temperature of from 140 to 150 degrees F. for a period of 30 minutes, and then quickly cooling it.
24. Fungi are totally dependent upon others for their life.
25. Bacteria of decay are most valuable to man.
26. Bacteria which live in the roots of legumes change nitrogen of the air to food for plants.
27. Forests supply humus to the soil and prevent erosion.
28. The most important service rendered by forests is in regulating the water supply.
29. Our greatest loss of forests is by fire which is usually preventable.
30. Rubber is an important plant product.
31. Loam is a fine sand which is mixed with a large quantity of decayed organic matter known as humus.
32. Clay is very fine, hard-packed soil which retains water well if allowed to soak in.
33. Fertilizers are substances used to replace elements taken from the soil by plants and all other elements.
34. Crop rotation is a method of rotation in which some crops add to the soil what other plants take out.
35. In the mouth the food is crushed and mixed with saliva.
36. Red corpuscles carry food and wastes to and from cells.
37. White corpuscles oppose the attack of disease germs.
38. Veins are vessels which carry blood back to the heart.
39. The brain consists of three regions: the cerebrum, the cerebellum, and the medulla.
40. Action that is not voluntary or regulated is called reflex action.
41. Repeated voluntary acts make nerve connections easier and we have a habit.
42. Involuntary reaction to stimulus is known as reflex action.

43. The eye is composed of the cornea, the iris, the lens muscle, the retina, and the optic nerve.
44. Common defects of the eyes are nearsightedness, farsightedness, and astigmatism.
45. Water is necessary as a food.
46. Vitamins are necessary for growth and normal health.
47. Alcohol is a narcotic which tends to cause diminishing nerve action and stupor.
48. In 1906 the Federal Pure Food and Drug Act was passed.
49. Proteins are compounds of all four elements C, H, O and N.
50. The two chief groups of carbohydrates are starches and sugars.
51. The Shick test tells whether an individual is liable to contract the disease if exposed to it.
52. The Dick test is a way of determining whether a person is susceptible to scarlet fever.
53. Cowpox inoculation gives persons resistance to smallpox germs.
54. Typhoid may be prevented by vaccination.
55. Milk is one of the best carriers of desease germs.
56. Heredity is the most powerful factor in determining the physical characteristics of all organisms.
57. Luther Burbank is noted for his selection and development of plants.

Chemistry

Concepts appearing in three texts:

1. Density of water.
2. Solvent power of water.
3. Action of acid on litmus.
4. Principle use of common bases.
5. General facts about metallic elements
   (a) Occurrence: Free Combined
   (b) General method of extraction
   (c) Power to conduct heat
   (d) Power to conduct electricity
6. Use of calcium compounds.
7. Ingredients of foods—Carbohydrates.

Geology

Concepts appearing in four texts:

1. Solar system
2. Nebulae
3. Planets
4. Vulcanism
5. Lavas
6. Erosion by water
7. Rocks formed by vulcanism
   (a) Igneous
   (b) Granite
8. Rocks formed by running water
   (a) Sedimentary

Concepts appearing in three texts:

1. Comets
2. Water table

Health

Concepts appearing in four texts:

1. How bacteria may be killed or kept from growing.

2. Specific diseases
   (a) Knowledge of tuberculosis
   (b) Knowledge of diphtheria.
   (c) Knowledge of typhoid
   (d) Knowledge of malaria and yellow fever

Concepts appearing in three texts:

1. Government protection of foods.
2. Methods of refrigeration.
3. Cause of food decay.
4. How to prevent food decay.
5. Prevention and spread of disease, by intermediate hostfly, mosquito, louse, tick, rat.
6. How disease germs enter the body.
7. Knowledge of colds.
8. Correct temperature of air in buildings.
9. Structure of the eye.
10. Effects of alcoholic beverages.
11. Results of poor heredity.
12. Heredity of man (general).
13. Methods of heating the home.

Physics

Concepts appearing in four texts:

1. Atmospheric pressure.
2. Friction.
3. Units of work.
4. Transmission of power.
5. Incline plane.
6. Pulley.
7. Wheel and axle.
8. Compound machines.
9. Source of heat.
10. Nature of heat.
11. Evidences of expansion.
12. Applications of heat expansions.
13. Heat units
    (a) Calorie
    (b) B.T.U.
14. Humidity.
15. Methods of distribution of heat.
    (a) Steam engines
    (b) Steam turbines
    (c) Gasoline engines
    (d) Diesel engines: Advantages, Disadvantages.
16. Sources of light.
17. Light terms: Reflection, absorption, transmission.
18. Lenses.
19. Microscope and magnifier.
20. Analysis of light.
21. Color of objects.
22. Frictional electricity.
23. Franklin's theory of electricity.
24. The electron theory.
25. Electrification.
26. Lightning.
27. The electric current.

28. Types of voltaic cells.
29. Units of electricity.
30. The use of cells.
31. Electric power—watts, K.W.H.
32. Measurement of resistance.
33. Dynamos or alternators.
34. Alternating current power.
35. Transformer—Power transmission.
36. History of radio.
37. Broadcasting—Transmission
—Receiving

Concepts appearing in three texts:

1. Definitions
   (a) Molecule (b) Proton (c) Electron (d) States of matter
2. Properties of matter.
   (a) Mass (b) Weight.
3. Laws of liquid pressure.
   (a) City water supply.
4. Fluids exert buoyant force: loss of weight by immersion.
5. Laws of flotation.
6. Hydrometer.
7. Barometers.
   (a) Aneroid (b) Mercury.
8. Weather maps.
   (a) Winds blow toward center of low.
   (b) Cyclone storms.
9. Simple and compound machines—the lever, the wedge.
10. Thermometers.
    (a) Centigrade (b) Fahrenheit.
11. Methods of distribution of heat.
    (a) Conduction (b) Convection (c) Radiation.
    (d) Heating systems.
12. Source and nature of sound.
13. Characteristics of a sound wave.
14. Graphic representation of sound.
15. Diffused light.
16. The camera.
17. Telescope.
18. Nature of magnetism.
19. Natural and artificial magnets.
20. Laws of magnets.
21. Magnetic field.
    (a) Lines of force
22. Magnetic induction of the earth.
23. Magnetism and electricity.
24. Series or parallel wiring.
25. The telephone.
26. Television.

Analysis of Findings for the Ninth Grade

The low degree of standardization of the content for graded junior high science is shown by the fact that only four units were common to three texts, and only eight other units were

common to two texts. The remaining twenty units were used only once by the several authors.

Only one topic was used uniformly by three authors, and they used it in developing two different units. Ten additional topics were used in developing nine units in two texts. A total of 132 different topics occurred only once in the development of 32 units, however, these units also contained the other topics mentioned above.

We find that the percent of the total concepts of the separate fields found in each text varied widely. In Astronomy the range of use of topics was from 28% to 92% of the total list, a difference of 64%. However, the author selecting only 28% of the concepts chose some that were not included in the 92% although the items may have been in one or more other texts.

Health was second in range of concepts with a difference of 40%. Here again there is considerable overlapping, but concepts were used in the text having the minimum number which did not appear in the maximum list.

In Geology the range was from 12% to 45%. There was a higher degree of uniformity in that no concept appeared in the minimum list which did not appear in the maximum.

In Biology the range was found to be 24%. Here again there was considerable overlapping but there were 21 concepts in the text with the minimum list which did not appear in the text with the maximum; thus we have a wide scattering in the content included.

The range in Physics was from 38% to 50%. This shows not only a rather narrow range but a very high percent of the total concepts appearing in each text. While there was considerable overlapping there were 18 concepts in the minimum text which did not appear in the maximum.

While the range in Chemistry was low, being only 9%, the maximum percentage of concepts was less than fifteen. Here again there were concepts appearing in the minimum list which did not appear in the maximum. Thus there is very little uniformity as to the concepts appearing in each text in a given major subject field.

In this paper we have shown that there is little agreement among the authors of the several books as to what content should be included at the various grade levels and in the definite subject matter areas. In the studies reported no attempt was made to determine the amount of space devoted to a given topic, so it

is not possible to state with any degree of accuracy the amount of learning which the authors expect the child to acquire on a given concept.

It is to be noted that there is considerable repetition of concepts from one book to another in the same series. Studies to determine the degree of vertical repetition, and the amount of space devoted to the presentation of repeatedly offered concepts are being made. The assumption has been made that the fullness with which an author presents a given concept is a measure of the degree of mastery which he expects with those materials. Some testing has been done to determine whether or not there is a difference in mastery where the topic is presented through several pages or in condensed form, but the results from these studies are not available at the present time.

If there is to be a major revision of the course in science in the upper high school grades, it must be based upon the existing junior high school program. Until more definite agreement has been reached pertaining to the content to be covered and the degree of completion to be achieved, the present program can not be used to plan a senior high school course revision. If there is to be an integrated course in the upper levels, it would seem that the junior high school program should be made more general, aimed toward exploration rather than understanding, and the course for the upper levels would cover only a few broad areas with a great deal more time devoted to an explanation of the science underlying and basic to an understanding of the forces, conditions, and materials of the environment. Heretofore, the science program has been extended *down* to the lower levels and teachers and authors have paid very little attention to their invasion of the higher areas. The result has been that teaching has not been improved, and much needless repetition has occurred from the wide range of use of concepts throughout all the series. It would appear that a much more valuable and teachable course in science could be written if attention of the experts, teachers, and curriculum workers could be directed to building a science program from the lower grades up.

To those interested in the construction of science units to fit their particular idea of a junior high school course or the needs of their local situation, careful study of the materials presented in these analyses will provide a ready-made outline complete to the extent of including the concepts to be taught.

KEY TO THE TEXTS

I. HUNTER AND WHITMAN, The March of Science Series, Book One, *My Own Science Problems*, American Book Company, Chicago, Ill., 1935.
II. CARPENTER-WOOD, Modern Science Series, Book One, *Our Environment: Its Relation to Us*, Allyn and Bacon, Chicago, Ill., 1937.
III. POWERS-NEUNER-BRUNER, A Survey of Science Series, Book One, *The World Around Us*, Ginn and Company, Chicago, Ill., 1934.
IV. WEED AND REXFORD, Useful Science Series, Book One, *Useful Science*, John C. Winston Company, Chicago, Ill., 1934.
V. BEAUCHAMP-MAYFIELD-WEST, Basic Studies in Science Series, Book One, *Science Problems*, Scott Foresman and Company, Chicago, Ill., 1938.

RESOURCEFULNESS IN TEACHING THE NEW ARITHMETIC

HARRIET E. GLAZIER
University of California, Los Angeles, California

Good teachers of arithmetic—new arithmetic, old arithmetic, or just plain arithmetic—do not merely happen. What then is the training for the teacher who knows and can explain to children the *why* and the *how* of the numerical side of common, everyday things about us? The following story may have something for us here.

A class of young men and women, graduates of reputable high schools, were preparing themselves for elementary teachers, and were making a study of measurement and measuring instruments. In particular they were to be ready for the question of the wide-awake child: why are our cans made round and so much the same in shape?

An assignment was given which included making a simple paper model to hold a gallon. No restriction or suggestion was made as to shape. An interesting variety of models appeared the following day: the easy factors 3, 7, 11 of the 231 cu. in. in a gallon made the rectangular shape popular—note the little red can at the gas station—; a couple of ambitious students undertook a cubical model, finding the approximate cube root of 231, by trial of course, since no one learns to do cube root in arithmetic today (this suggested the story of the age-old problem of the "Duplication of the Cube," and the question of finding the edge of a cube of given volume); there was one sphere; a few cylinders of various heights and bases, and even a paper sack

cut off at the proper height. Not to miss anyone the class was asked if there were others, when one student brought out a closed tube folded flat along the length and then folded evenly again but without any hint as to the shape of the base. Asked what shape had been intended for the base the reply was: "It doesn't make any difference—it would be the same if fitted around a square base as if fitted around a circular one." This led to the question, is the volume the same, and if not which would give the greater contents?

There was evidently a variety of opinion. Many held the shape of the base made no difference while others insisted, some that the square base would give better capacity, others the circular base, and the question was left open to be investigated and reported on the next day, with an added study of the question: "If the gallon container were a cylinder would the amount of material needed to construct it be the same regardless of relative dimensions, or was there *one* shape that would require the *least* material for its construction?

The opening of class the next hour found the students busily discussing their results. To the suprise of the majority they had found the circular base gave decidedly better capacity than the square base of equal perimeter—that a given wall gave greater volume if fitted to a circular base than if fitted to a square base. They had begun to see why so many gas and water tanks, glass jars and even tin cans are cylindrical in shape—notwithstanding the fact that space is lost in the packing boxes.

When, however, the question arose—is there a *best* set of dimensions—height and diameter of the base—for a cylindrical container to hold our 231 cu. in. and use the least material—no one was eager to proffer an opinion. It seemed as though the question must go unanswered, when one modest young woman timidly raised her hand and said: "My brother has studied *calculus*, and he told me that they worked this question out in their calculus class and the model that required the least material for a given volume was a cylinder with the height the same as the diameter of the base." A moment's reflection and many were ready to admit having seen cans made after such a model.

This study of the simple but extremely practical question of maximum volume and minimum construction material in a field quite familiar to the boy and girl of sixth, seventh or eighth grade arithmetic (that of ordinary measurement), suggests how

a skilful teacher of those grades may use data gathered from other courses to arouse interest and to enrich the work of those years. This is but one of many such possibilities and the question remains: Not how much mathematics can the teacher of arithmetic get along without, but rather how much can the skilful teacher profitably know, and use, of what is commonly called "mathematics" in teaching the wide-awake boy or girl the plain ordinary subject of everyday arithmetic?

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers, College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

1664. *Proposed by Harry Frye, Tullahoma, Tenn.*

If the sum of 636 consecutive odd numbers is a cube, what are the numbers?

Solution by Cecil E. Leith, Jr., Scituate, Massachusetts

$S = n/2[2a + (n-1)d]$, where $n = 636$, $d = 2$
$S = 381\ (2a + 1270)$ from which
$2a + 1270 = 318^2 = 101124$
$a = 49927$. Hence the 636 numbers are 49927, 49929, . . . , 51197

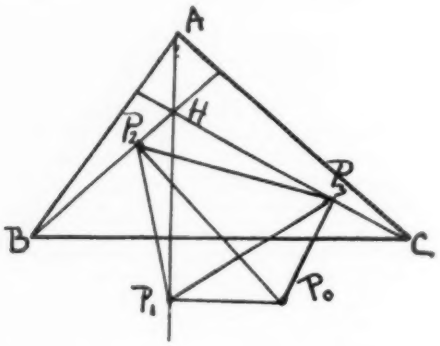
Solutions were also offered by Vaughn Agy, Jackson, Tenn., B. Felix John, Pittsburgh, John F. Wagner, Chicago, Alan Wayne, New York City, Paul C. Overstreet, Wilmore, Ky., C. W. Trigg, Los Angeles City College, George J. Ross, Brooklyn, N. Y., John P. Hoyt, Cornwall, N. Y., Harry Frye, Tullahoma Tenn., Walter R. Warner, Rochester, N. Y.

1665. *Proposed by Chas. W. Trigg, Los Angeles City College.*

The orthogonal projections of any point in the plane of a triangle upon the altitudes of the triangle are the vertices of a triangle similar to the given triangle.

Solution by George J. Ross, Brooklyn, N. Y.

Let P_0 be the given point and P_1, P_2, P_3, its projections on the altitude.
Hence $\angle P_1P_0P_2 = \angle BCA$
and $\angle P_2P_0P_3 = \angle BAC$ since their sides are parallel.
Now P_1, P_2, P_3 lie on a $\odot$ with diameter P_0H since the angles at P_1, P_2, P_3 are right angles and P_0H is the hypotenuse of the triangles formed.
$\therefore \angle P_2P_1P_3 = \angle P_2P_0P_3 = \angle BAC$ and $\angle P_2P_3P_1 = \angle P_1P_0P_2 = \angle BCA$
$\therefore \triangle P_1P_2P_3 \sim \triangle ABC$.



Solutions were also offered by David L. MacKay, Evander Childs High School, New York City, M. Kirk, West Chester, Pa., and the proposer.

1666. *Proposed by Cecil B. Read, Wichita, Kan.*

If ABC and ABD are equilateral triangles in perpendicular planes, find the angle CAD.

Solution by A. MacNeish, Chicago, Ill.

Let P and P' be the perpendicular planes; line AB, their line of intersection; DM, the altitude of $\triangle ABD$; CM, the altitude of $\triangle ABC$; s, the side of each equilateral $\triangle$; and x, the line CD.
DM lies in P' and is $\perp$ to P. Therefore DM is $\perp$ to MC.

$$DM \text{ and } MC \text{ each} = \frac{s}{2}\sqrt{3}.$$

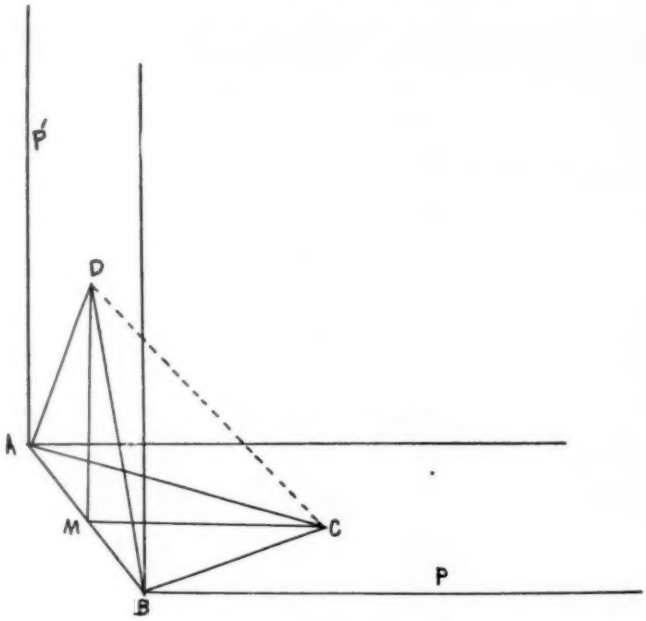
$$x^2 = \frac{3s^2}{4} + \frac{3s^2}{4}. \qquad \therefore \ \frac{s}{2}\sqrt{6} = x$$

$$\cos CAD = \frac{s^2+s^2-x^2}{2s^2} = \frac{s^2+s^2-\frac{3s^2}{2}}{2s^2} = \frac{1}{4} \quad \text{or} \quad .2500.$$

Therefore $\angle CAD = 75°31'20''$.

Solutions were also offered by B. Felix John, Pittsburgh, Pa., Joseph B. Waller, Boyd, Minn., George J. Ross, Brooklyn, N. Y., David L. MacKay, Evander Childs High School, New York, Paul C. Overstreet, Wilmore, Ky., Conrad Hermanson, Spokane, Wash., M. Kirk, West Chester,

Pa., C. W. Trigg, Los Angeles City College, John W. Sevensson, Evanston, Ill., John P. Hoyt, Cornwall, N. Y., Clarence S. Warne, Romulus, N. Y., Walter R. Warne, Rochester, N. Y., Kenneth P. Carlson, Funk, Neb., and the proposer.



1667. *Proposed by Cecil B. Read, University of Wichita.*

If $2x$ is a positive acute angle show that $\cot x - \cot 4x > 2$

Solution by Alan Wayne, New York City

Since $\cot x = \dfrac{1+\cos 2x}{\sin 2x}$ and $\cot 4x = \dfrac{\cot^2 2x - 1}{2\cot 2x} = \dfrac{\cos^2 2x - \sin^2 2x}{2\sin 2x \cos 2x}$

$$\therefore \quad \cot x - \cot 4x = \frac{2\cos 2x + 1}{2\sin 2x \cos 2x}$$

or

$$\cot x - \cot 4x = \csc 2x + \csc 4x. \quad \text{Since } 0 < 2x < 90°,\ 0 < 4x < 180°,$$

then

$$\csc 2x > 1 \quad \text{and} \quad \csc 4x > 1. \qquad \therefore \quad \cot x - \cot 4x > 2.$$

Solutions were also offered by C. W. Trigg, Los Angeles City College, George J. Ross, Brooklyn, N. Y., John P. Hoyt, Cornwall, N. Y., Paul C. Overstreet, Wilmore, Ky., B. Felix John, Pittsburgh, Pa., M. Kirk, West Chester, Pa., David L. MacKay, Evander Childs High School, New York, Walter R. Warne, Rochester, N. Y., Vaughn Agy, Lambeth College and also by the proposer.

1668. *Proposed by B. Felix John, Pittsburgh, Pa.*

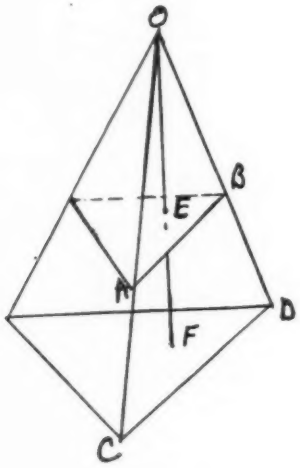
A plane parallel to the base of a pyramid divides the lateral area into equal parts. In what ratio does the plane cut the altitude.

Solution by John F. Wagner, Chicago

Let O be the vertex of our pyramid; CD the base of the triangular face; and AB, the edge at which the parallel plane cuts the triangular face.

$$\text{(1)} \qquad \frac{\text{Area } \triangle OCD}{\text{Area } \triangle OAB}=2=\frac{OF^2}{OE^2},$$

where F is the point at foot of altitude and E is the point where OF cuts the parallel plane.



$$\text{(2)} \qquad \frac{OE}{OF}=\frac{1}{\sqrt{2}}.$$

But this is the ratio of the upper portion to the whole altitude.

$$\text{(3} \qquad \frac{OE}{EF}=\frac{OE}{OF-OE}=\frac{1}{\sqrt{2}-1}=\frac{\sqrt{2}+1}{1}.$$

Therefore the altitude is cut in the ratio $(\sqrt{2}+1):1$.

Solutions were also offered by Alan Wayne, New York City, C. W. Trigg, Los Angeles City College, Roy Wild, New Boston, Mo., W. R. Smith, Suttons Bay, Mich., and also by the proposer.

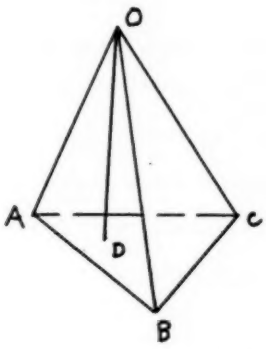
1669. *Proposed by John P. Hoyt, Cornwall, N. Y.*

If three edges of a tetrahedron, of lengths a, b, and c, are mutually perpendicular and concurrent at one vertex of the tetrahedron prove (by elementary geometry) that the remaining altitude of the tetrahedron is equal to:

$$\frac{abc}{a^2b^2+a^2c^2+b^2c^2}.$$

Solution by George J. Ross, Brooklyn, N. Y.
First Solution

Let OA, OB, and OC be the mutually perpendicular edges a, b, c and OD, the altitude, h, to face ABC.



(1) $\qquad$ Volume $=\frac{1}{3}a\times$Area $\triangle OBC=\frac{1}{3}h\times$Area $\triangle ABC$.

Since the faces OAB, OBC, OAC are right $\measuredangle$s

$$AC=\sqrt{a^2+c^2}, \qquad AB=\sqrt{a^2+b^2}, \qquad BC=\sqrt{b^2+c^2}.$$

By the cosine law

$$\cos B=\frac{b^2}{\sqrt{(a^2+b^2)(b^2+c^2)}}$$

$$\therefore \quad \sin B=\frac{\sqrt{a^2b^2+b^2c^2+c^2a^2}}{\sqrt{(a^2+b^2)(b^2+c^2)}}$$

(2) $\qquad \therefore$ Area $\triangle ABC=\frac{1}{2}\sqrt{a^2b^2+b^2c^2+c^2a^2}$

(3) $\qquad$ Area rt. $\triangle OBC=\frac{1}{2}bc$.

Substituting (2) and (3) in (1)

$$h=\frac{abc}{\sqrt{a^2b^2+b^2c^2+c^2a^2}}.$$

Note: The formula for the area in terms of the side could have been used to find the area of ABC.

Second Solution

A solution using analytics is offered.

Let OA, OB, OC be the mutually perpendicular edges a, b, c. Let O be the origin and these edges the axes.

The equation of plane ABC is

$$\frac{x}{a}+\frac{y}{b}+\frac{z}{c}=1$$

and the distance from the origin is the altitude

$$OD=\frac{1}{\sqrt{\frac{1}{a^2}+\frac{1}{b^2}+\frac{1}{c^2}}}$$

$$= \frac{abc}{\sqrt{a^2b^2+b^2c^2+c^2a^2}}.$$

Solutions were also offered by Roy Wild, New Boston, Mo., David L. Mackay, N. Y., C. W. Trigg, Los Angeles City College, and also by the proposer.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

For this issue the Honor Roll appears below:

1665–9. Cecil F. Leith, Jr., Scituate (Mass.) H. S.

PROBLEMS FOR SOLUTION

1681. *Proposed by Charles P. Louthan, Columbus, Ohio.*

A square hole 4 in. by 4 in. is punched vertically through a horizontal cylinder of radius 5 in., two sides of the hole being parallel to and 2 in. from the axis of the cylinder. Find the area and the volume cut out. (Taken from Griffin's *Mathematical Analysis* V. II, p. 226.)

1682. *Proposed by E. H. Cooper, South Bend, Ind.*

Find the sides of an inscribed quadrilateral, such that its area will be $\sqrt{(x+1)!}$, x being the length of the longest side.

1683. *Proposed by C. W. Trigg, Los Angeles*

ae^x+be^{-x} can be written in the form $r(e^{x+c}+e^{-x-c})$, where r and c are fixed numbers. Find r and c.

1684. *Proposed by Walter R. Warne, Rochester, N. Y.*

If a and b are positive integers, show that

$$\frac{(2a)!(2b)!}{a!b!(a+b)!}$$

is an integer.

1685. *Proposed by H. D. Groosman, N. Y. C.*

Find the principal value of $\sqrt[\sqrt{-1}]{-1}$.

1686. *Proposed by Arthur Brooks, Ledger, N. Y.*

If a and b are positive and $a+b=1$, show that

$$\left(a+\frac{1}{a}\right)^2+\left(b+\frac{1}{b}\right)^2 \geqq \frac{25}{2}.$$

NON-INFLAMMABLE LATH

Non-inflammable lath board is now on the market. It is made of minute flakes of a non-metallic mineral which originates in mica. These are interlaced with wood fibers so that there are millions of microscopic fire-walls in each panel. A partition so constructed was tested and prevented the spread of fire from one room to another for more than an hour.

SCIENCE QUESTIONS

November, 1940

Conducted by Franklin T. Jones,
10109 Wilbur Avenue, S.E., Cleveland, Ohio

SOME QUESTIONS ABOUT RAILROADS

106. What is the weight of a steam locomotive?
Of an electric locomotive?
107. How much boiler tubing is there in a locomotive?
108. How much labor goes into the construction of a steam locomotive?
109. How much contact is there between the wheel of a locomotive or car and the rail?
110. How many passengers could be seated in all steam railway passenger cars at one time?

(The above questions are taken or adapted from "QUIZ on Railroads and Railroading"—400 Questions—which may be obtained free from Association of American Railroads, Transportation Building, Washington, D. C.)

ANSWERS FOR JUNE, 1940

96. A bloodstain is green when mixed with the dye of fabric or wall-paper.
97. About 25,000,000 red blood corpuscles are formed in the marrow of the bones per second.
98. A lie detector catches you in a lie by registering changes in your heart action and breathing.
99. Light will pass through a vacuum but sound will not.
100. The South Magnetic Pole is generally believed to cover an area of about ten miles square and apparently shifts from year to year.

WANTED—TESTS—QUESTIONS—ANSWERS—EXAMINATION PAPERS

LOST—Somewhere between San Francisco and Niagara Falls, the green book in which I keep track of contributors and questions and their answers. This book carried the names of those who should be credited with new membership in the GQRA. If your name should appear in the November, 1940, issue as a NEW MEMBER, please write and inform F. T. JONES, 10109 Wilbur Avenue, S.E., Cleveland, Ohio.

PRESSURE AND HEAT OF VAPORIZATION

898. *Proposed by Robert E. McKay, GQRA, No. 172, Middleport, Ohio.*

"I wish to submit a science question for your department of SCHOOL SCIENCE AND MATHEMATICS. *I do not recall having seen an answer to it in any of the physics text-books."*

What is the effect of pressure upon the heat of vaporization? Or, to be more direct, how does the heat of vaporization (water—538 calories per gram at 100°C.) vary with a rise or fall of the boiling point?

CONCLUSIONS—RIGHT OR WRONG?

899. *Proposed by Philip B. Sharpe, GQRA, No. 262, Greenwich, N. Y.*

A pupil filled a beaker with ice-water and held it over a Bunsen flame to see if the gas was hydrogen. Drops of water collected on the outside of the beaker and he concluded that the answer was—"Yes."

(a)—Give three reasons why this experiment fails to justify the conclusion, or, give three other possible explanations of the observation.

(b)—Explain briefly why an experiment must be carefully controlled to be convincing.

ARE YOU A THINKER?

900. *From "Brain Teasers" edited by Carl D. Thompson in "The Double Bond," publication of Western New York Section of American Chemical Society. Mr. Thompson is elected to the GQRA. His number is 351.*

"The ocean liner S. S. *Montauk* was anchored in New York harbor. A spectator on the dock noticed a ladder hanging from the topsides. Furthermore, he noticed that the bottom four rungs of the ladder were just submerged, that each rung was 2 inches wide and that the rungs were 11 inches apart. If the tide was rising at the rate of 18 inches per hour, how many rungs would be submerged at the end of two hours?"

GENERAL SCIENCE EXAMINATION—January, 1940

901. *Submitted by C. S. Greenwood, GQRA, No. 136, Sheffield, Pa.*

Place a plus before the true statements and a zero before the false statements:

____ 1. A real image may be produced by a plane mirror.
____ 2. A blue dress appears blue in daylight because its own color added to sunlight gives blue.
____ 3. There is a neap tide at the time of an eclipse of the moon.
____ 4. A beam of light will be bent when it goes from air into glass at an angle of 90 degrees.
____ 5. A blue dress appears blue in daylight because the material absorbs all of the sunlight except blue.
____ 6. There is a spring tide at the full of the moon.
____ 7. The Big Dipper is a constellation.
____ 8. A thought is made of matter.
____ 9. According to the planetesimal hypothesis the earth was once colder than it is now.
____ 10. The earth would appear like a bright star if seen by people on a planet near the North Star.
____ 11. Ultra-violet rays are the shortest waves the eye can detect.
____ 12. Jupiter belongs to the solar system.
____ 13. The earth was once the center of the solar system and all the heavenly bodies revolved around it.
____ 14. The ether is supposed to weigh the same as hydrogen.
____ 15. The intensity of illumination depends upon the strength of the source of light and the distance from the light.
____ 16. Ultra-violet rays are invisible.
____ 17. The moon belongs to the solar system.
____ 18. If you cross the International Date Line going west on Thursday you call the day Friday.
____ 19. The ether is supposed to be a form of energy.
____ 20. Glare is caused by a bare light in the field of vision.
____ 21. Ultra-violet rays are transmitted through quartz glass better than through ordinary window glass.
____ 22. The North Star belongs to the solar system.
____ 23. If your watch indicates daylight-saving time in New York and your friend has his set to standard time in Chicago, the two watches will read alike.
____ 24. Glare is caused by glossy paint and polished metals.

____ 25. Ultra-violet rays are helpful in preventing rickets.
____ 26. The sun belongs to the solar system.
____ 27. A pendulum clock has a balance wheel.
____ 28. Water is a compound.
____ 29. The camera lens reflects the light from the object.
____ 30. We depend largely upon the sun for our heat.
____ 31. The sun is self-luminous.
____ 32. The use of the scientific method helps one to think straight.
____ 33. The camera lens refracts the light coming into it.
____ 34. The sun has an important influence on the temperature of the earth.
____ 35. Light travels 1,100 feet per second.
____ 36. There is a spring tide at the time of an eclipse of the sun.
____ 37. A blue dress appears blue in daylight because its own color added to the sunlight gives blue.

GENERAL INFORMATION TEST—UNIVERSITY SCHOOL, CLEVELAND

902. *From Charles R. Foster (Elected to the GQRA, No. 352), Head of History Department, University School, Cleveland, Ohio.*

For many years, certainly twenty-five, a General Information Test has been given competitively at US. This is given under various headings. Part V—Science-Invention follows.

Mr. Foster has written these questions for quite a number of years. This list is used by permission since the entire list is copyrighted by Charles R. Foster.

(a)—Who made the first practical application of steam to industry?
(b)—What country is experimenting in the making of "butter-coal"?
(c)—Who invented the sewing machine? Who invented vulcanization of rubber?
(d)—What woman scientist specialized in the study of radium?
(e)—To what profession did Harvey Cushing belong?
(f)—Insulin is used in the treatment of what disease?
(g)—From what two metals is bronze made?
(h)—What is the main difference between physics and chemistry?
(i)—What is a planetarium?
(j)—Name an invention associated with the name of each of the following men: 1—Cyrus McCormick, 2—Eli Whitney, 3—Marconi, 4—Morse.

SCRAMBLED WORDS—AN ANSWER

894. *Proposed by Marian Berres, GQRA, No. 342, Mercy High School, Milwaukee, Wis.*

"When we had our monthly meeting of the Mercy Bio-ite Club, I made up a game of "Scrambled Words." Very few girls were able to unscramble them. Four girls unscrambled five words out of the ten. I wonder if the readers of SCHOOL SCIENCE AND MATHEMATICS could unscramble them." *Answers as given by Marian.*

1)—ylacriortuc ..... circulatory.
2)—lapfinaol ..... Fallopian.
3)—rtaegacli ..... cartilage.
4)—meligant ..... ligament.
5)—altepla ..... patella.
6)—raymlalch ..... lachrymal.
7)—upaclas ..... scapula.

8)—spnrioet.....proteins.
9)—snohiped.....sphenoid.
10)—mymaram.....mammary.
(In each case the definition of the "scrambled" word was given as a clue.)

THE GUILD OF QUESTION RAISERS AND ANSWERERS

This Guild—GQRA—was first announced in January, 1934, taking in as charter members those who contributed in the school year, October, 1933, to December, 1933. The thirteen original members were—1. John C. Packard, 2. Walter E. Hauswald, 3. Walter C. Pribnow, 4. William W. Johnson, 5. A. G. Zander, 6. F. R. Bemisderfer, 7. William Malkin, 8. Clyde W. Holt, 9. Senior Physics Class, Norwich Free Academy, Harold Geer, Secretary, 10. Carroll E. Lowe, 11. Marshall Brown and Chemistry Class, Gilmer, Texas, 12. A. H. Gould, 13. H. K. Moore.

From October, 1933, through September, 1940, there have been 352 different contributors to SCIENCE QUESTIONS DEPARTMENT. Many members have contributed several times.

To all contributors and readers of the Department the Editor is extremely grateful. It has been interesting and inspiring to correspond with contributors. An attempt has been made to acknowledge every contribution, frequently by picture cards which the Editor has picked up on his travels in this period of years. It would have been most interesting to have kept track of all the contributors since the beginning of the Department some twenty-five or thirty years ago. They have been scattered all over the world—the Philippines, India, Sweden, England, Ireland, Canada, Alaska, Brazil, Argentina, Mexico, France, Germany, Spain, and almost every state in the Union. Many contributors have been outside the teaching profession. Thanks for your contributions and I hope you have enjoyed the reading as much as I have the editing. FTJ.

GQRA—NEW MEMBERS—November, 1940

351. *Carl D. Thompson, The "Double Bond," Niagara Falls, New York.*
352. *Charles R. Foster, Head, Department of History, University School, Cleveland, Ohio.*

JOIN THE GQRA

BOOKS AND PAMPHLETS RECEIVED

A TEXT-BOOK OF HEAT, by H. S. Allen, *Professor of Natural Philosophy in the University of St. Andrews*, and R. S. Maxwell. Part II. Cloth. Pages ix+318+xi. 13.5×22 cm. 1939. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $3.50.

NEW WORLD OF CHEMISTRY, by Bernard Jaffe, *Chairman, Department of Physical Science, Bushwick High School, New York City*, and *author of "Outposts of Science, Crucibles, and Chemical Calculations."* Cloth. Pages xi+692. 14×20.5 cm. 1940. Silver Burdett Company, 45 East 17th Street, New York, N. Y. Price $1.84.

A STUDY OF THE PROBLEMS IN TEACHING THE SLIDE RULE, by Carl N. Shuster. Teachers College, Columbia University *"Contributions to Education, No. 805."* Cloth. Pages v+103. 14.5×23 cm. 1940. Bureau of Publications, Teachers College, Columbia University, New York, N. Y. Price $1.85.

CALCULATIONS OF QUALITATIVE ANALYSIS, by Louis J. Curtman, *Professor of Chemistry*, and Sylvan M. Edmonds, *Instructor in Chemistry, The City College, The College of the City of New York*. Cloth. Pages vii+156. 15×23 cm. 1940. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $2.00.

SAFETY, by Sidney J. Williams, *Director of Public Safety Division, Formerly Chief Engineer, National Safety Council*, and W. W. Charters, *Director of the Bureau of Educational Research, Ohio State University*. Cloth. Pages viii+451. 13.5×21.5 cm. 1940. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $1.60.

LABORATORY AND WORKBOOK UNITS IN CHEMISTRY, by Maurice U. Ames, *Chairman, Department of Physical Sciences, George Washington High School, New York City*, and Bernard Jaffe, *Chairman, Department of Physical Sciences, Bushwick High School, New York City*. Paper. Pages xx+267. 18.5×26 cm. 1940. Silver Burdett Company, 45 East 17th Street, New York, N. Y. Price 92 cents.

JUNIOR MATHEMATICS, Books 1, 2 and 3, by Harl A. Douglass, *Director, College of Education, University of Colorado*, and Lucien B. Kinney, *Associate Professor of Education, Stanford University*. Cloth. Book 1, vii+440 pages; Book 2, vii+439 pages; and Book 3, vii+504 pages. 12.5×20 cm. 1940. Henry Holt and Company, 257 Fourth Avenue, New York, N. Y.

THE DEVELOPMENT OF MATHEMATICS, by E. T. Bell, *Professor of Mathematics, California Institute of Technology*. First Edition. Cloth. Pages xiii+583. 15×23 cm. 1940. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y. Price $4.50.

THIS LIVING WORLD, by C. C. Clark, *Associate Professor of General Science, New York University*, and R. H. Hall, *Instructor in General Science, New York University*. First Edition. Cloth. Pages x+519. 15×23 cm. 1940. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y. Price $3.25.

MATHEMATICS FOR TODAY, Books 1 and 2, by Harl R. Douglass, *Director, College of Education, University of Colorado*, and Lucien B. Kinney, *Associate Professor of Education, Stanford University*. Cloth. Book 1, vii+437 pages; Book 2, vii+447 pages. 12.5×20 cm. 1940. Henry Holt and Company, 257 Fourth Avenue, New York, N. Y.

EVERYDAY MATHEMATICS, by Harl R. Douglass, *Director, College of Education, University of Colorado*, and Lucien B. Kinney, *Associate Professor of Education, Stanford University*. Cloth. Pages vii+503. 1940. Henry Holt and Company, 257 Fourth Avenue, New York, N. Y.

TIME AND ITS RECKONING, by R. Barnard Way and Noel D. Green. Cloth. Pages viii+137. 13.5×21.5 cm. 1940. The Chemical Publishing Company, Inc., 148 Lafayette Street, New York, N. Y. Price $2.00.

STATISTICAL PROCEDURES AND THEIR MATHEMATICAL BASES, by Charles C. Peters, *Director of Educational Research, The Pennsylvania State College*, and Walter R. Van Voorhis, *Schuylkill Administrative Head and Assistant Professor of Mathematics, The Pennsylvania State College*. First Edition. Cloth. Pages xiii+516. 1940. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y. Price $4.50.

WILEY TRIGONOMETRIC TABLES. Flexible Binding. Pages iii+81. 14×

21.5 cm. 1937. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price 75 cents.

A COURSE OF ANALYSIS, by E. G. Phillips, *Senior Lecturer in Mathematics in the University College of North Wales, Bangor; formerly Senior Scholar of Trinity College, Cambridge.* Cloth. Pages vi+361. 13.5×21.5 cm. 1939. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $4.00.

COLLEGE MATHEMATICS, A FIRST COURSE, by W. W. Elliott, *Professor of Mathematics and Director of Undergraduate Studies in Mathematics, Duke University*, and E. Roy Miles, *Assistant Professor of Mathematics, Duke University.* Cloth. Pages xiii+396. 15×23 cm. 1940. Prentice-Hall, Inc., 70 Fifth Avenue, New York, N. Y. Price $3.00.

ASTRONOMY. A Guide for Use with the Instructional Sound Films "The Earth in Motion," "The Solar Family," "The Moon," and "Exploring the Universe," prepared by Melvin Brodshaug, *Erpi Classroom Films Inc.*, James A. Fraser and Catherine M. Bergen, *Advanced School, Teachers College, Columbia University* in Collaboration with Walter Bartky, *The University of Chicago.* Paper. Pages vi+53. 13.5×20 cm. 1940. The University of Chicago, 5750 Ellis Avenue, Chicago, Ill. Price 15 cents.

WORKBOOK TO UNDERSTANDING SCIENCE, WORKBOOK TO SCIENCE FOR HUMAN CONTROL, WORKBOOK TO SCIENCE FOR DAILY USE, by Ralph K. Watkins, *Professor of Education, School of Education, University of Missouri*, and Winifred Perry, *Teacher of General Science, Roosevelt Junior High School, San Diego, California.* Paper. *Understanding Science* has v+106 pages, *Science for Humon Control* iv+122 pages, *Science for Daily Use* iv+116 pages. 20×27.5 cm. 1940. The Macmillan Company, 60 Fifth Avenue, New York, N. Y.

THE INTERVIEW METHOD OF TEACHING QUALITIVE ANALYSIS, by Alfred M. Ewing, *Professor of Chemistry, Texas Wesleyan College, Fort Worth, Texas.* Revised and enlarged. Paper. 52 pages. 20×27.5 cm. 1940. Published by the author. Sample copy $1.00, discounts for quantity order.

ADVENTURES IN BIOLOGY, by Julius Schwartz, Louis Eisman, James Mandel, Jerome Metzner, Mildred Narins, Abraham Penzer, Charles Tanzer, Susan Tanzer, and Richard Weiss, *Teachers of Biology in the High Schools of the City of New York.* Paper. Pages vii+101. 13×21.5 cm. 1940. New York Association of Biology Teachers, Grover Cleveland High School, Brooklyn, N. Y. Price 50 cents. A 20% discount will be allowed for orders of 10 or more copies to be sent to the same address.

NEGRO HIGH-SCHOOL GRADUATES AND NONGRADUATES, by Ambrose Caliver, *Senior Specialist in the Education of Negroes.* Pamphlet No. 87. Pages iii+19. 14.5×23 cm. 1940. Superintendent of Documents, Washington, D. C. Price five cents.

DEVELOPMENT AND MANUFACTURE OF OPTICAL GLASS IN AMERICA, by M. Herbert Eisenhart and Everett W. Melson, *Bausch and Lomb Optical Company.* Reprinted from *The Scientific Monthly* April, 1940, Vol. L, pages 323–334.

TABLES FOR CALCULUS, by C. K. Robbins and Neil Little. *Purdue University.* Paper. 22 pages. 15×23 cm. 1940. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price 15 cents.

PUBLIC EDUCATION IN THE PANAMA CANAL ZONE, by Katherine M.

Cook, *Chief, Division of Special Problems, Office of Education*. Bulletin 1939, No. 8. Pages v+63. 15×23.5 cm. Superintendent of Documents, Washington, D. C. Price 15 cents.

OPPORTUNITIES FOR STATISTICAL WORKERS, by Donald E. V. Henderson, *University of Alabama*. Second Edition. Paper. 56 pages. 15×23 cm. 1940. Science Research Associates, 600 South Michigan Avenue, Chicago, Ill. Price 50 cents.

EMPLOYMENT IN LAND TRANSPORTATION, by Felix B. Streyckmans, *Chicago Junior Association of Commerce*. Second Edition. Paper. 48 pages. 15×23 cm. 1940. Science Research Associates, 600 South Michigan Avenue, Chicago, Ill. Price 50 cents.

CAREERS IN CONSUMER COOPERATION, by Clarence Walker Failor, *Director of Vocational Guidance and Placement Service Proviso Township High School, Maywood, Illinois*. Second Edition. Paper. 48 pages. 15×23 cm. 1939. Science Research Associates, 600 South Michigan Avenue, Chicago, Ill. Price 50 cents.

JOBS IN RURAL JOURNALISM, by Elmo Scott Watson, *Editor, The Publishers' Auxiliary; Lecturer, Medill School of Journalism, Northwestern University*. Second Edition. Paper. 48 pages. 15×23 cm. 1939. Science Research Associates, 600 South Michigan Avenue, Chicago, Ill. Price 50 cents.

TEACHING AS A CAREER, by Cyril O. Houle, *The Department of Education, The University of Chicago*. Second Edition. Paper. 48 pages. 15×23 cm. 1940. Science Research Associates, 600 South Michigan Avenue, Chicago, Ill. Price 50 cents.

OCCUPATIONS IN RADIO, by Kenneth G. Bartlett, *Director of the Radio Workshop, Syracuse University*, and Douglass W. Miller, *Assistant to the Dean, School of Journalism, Syracuse University*. Paper. 48 pages. 15×23 cm. 1940. Science Research Associates, 600 South Michigan Avenue, Chicago, Ill. Price 50 cents.

JOBS IN HORTICULTURE, by Gilbert W. Wernicke, *Instructor, Horticulture and Plant Biology, Lakewood High School, Lakewood, Ohio*. Paper. 48 pages. 15×23 cm. 1940. Science Research Associates, 600 South Michigan Avenue, Chicago, Ill. Price 50 cents.

PROJECT KIT, by Ernestine M. J. Long, *Normandy High School, St. Louis, Missouri, for Chemistry Section, Central Association Science and Mathematics Teachers and Missouri and St. Louis Junior Academies of Science*. Mimeographed. 21.5×28 cm. 1939. Price 35 cents.

PROJECT KIT TWO, by Ernestine M. J. Long, *Normandy High School, St. Louis, Missouri, for Kansas, Virginia, Texas, Missouri, and St. Louis Junior Academies of Science*. Mimeographed. 21.5×28 cm. 1940. Price 35 cents.

BALOPTICONS AND ACCESSORIES. Catalog E-11. 28 pages. 21.5×28 cm. Bausch and Lomb Optical Company, Rochester, N. Y.

NEW WORLDS IN ENGINEERING, by Chrysler Corporation, 89 pages. 21.5×28 cm. 1940. Chrysler Corporation, Detroit, Michigan.

RAILWAY LITERATURE FOR YOUNG PEOPLE. 1940 Edition. 9.5×23 cm. Association of American Railroads, Transportation Building, Washington, D. C. Distributed free.

BOOK REVIEWS

THE TRAINING OF MATHEMATICS TEACHERS FOR SECONDARY SCHOOLS IN ENGLAND AND WALES AND IN THE UNITED STATES, by Ivan Stewart Turner. Cloth. Pages xiii+231, 13×23 cm. 1939. Bureau of Publications, Teachers College, Columbia University, New York, N. Y. Price $1.75.

The book under review is the fourteenth yearbook of the National Council of Teachers of Mathematics. This book presents the results of an investigation of the training of teachers for the teaching of mathematics in the United States and in England and Wales. The results of the investigation are recorded in eight chapters.

The introductory chapter presents the purpose of the study, previous studies, and the sources of data.

The second chapter sets up nine fundamental principles which are believed to be fundamental in the training of mathematics teachers.

The third chapter deals with the character of secondary education in England and Wales and in the United States. A comparison between the secondary curricula discloses the fact that much more attention is given to mathematics in England than in the United States.

The fourth chapter presents in some detail the character of secondary instruction in mathematics in England and American schools.

The fifth and sixth chapters discuss respectively the academic and professional training of teachers.

The seventh and eighth chapters present a summary, comparison, and an evaluation in terms of the principles set forth in the second chapter.

Every teacher of mathematics should be interested in this fourteenth yearbook.

J. M. KINNEY

FUNDAMENTALS OF COLLEGE PHYSICS, by Willibald Weniger, *Professor of Physics, Oregon State College*. Cloth. Pages viii+694. 1940. American Book Company, 300 Pike Street, Cincinnati, Ohio. Price $3.75.

This new text for general physics classes in college is orthodox in type. In general form and content it is not radically different from other standard texts now in use. The author states that throughout the text he has emphasized the concept of motion. This may be considered the characteristic trait but it is not played up to the extent that it is particularly evident to the student or teacher unless his attention has been called to it. The book is decidedly "classical" with just a mere touch of modern physics here and there.

Some teachers will object to the discussion of "centrifugal" force and to mention of such units as the gravital and the slug. A short chapter on the theory and applications of the gyroscope, and one on curves and their uses are somewhat unusual, as are such topics as those on the Mohr balance, the Baumé gravity scale, and vortex motion. Excursions into modern physics are made in the chapter on the discharge through gases and the one on quanta or photons. The chapter on the production of light is outstanding and brings the story of the evolution of the incandescent lamp up to the minute.

Teaching helps are present in suggested experiments, lists of questions and problems, and review outlines. The book shows careful preparation and merits consideration.

G. W. W.

UNDERSTANDING RADIO, by Herbert M. Watson, *Associate Member I. R. E.;* Herbert E. Welch, *Associate Professor of Radio Technology and*

Engineering, Stockton Junior College, Stockton, California; and George S. Eby, *Professor of Applied Science, Stockton Junior College, Stockton, California.* Cloth. Pages ix+603. 13.5×20.5 cm. 1940. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y. Price $2.80.

This is a combined textbook and laboratory manual for beginners. It covers all elementary theory adequately but major emphasis is placed on practical construction and operation. By a conversational style of writing the authors seem to be actually present to explain each step. Many excellent diagrams, short paragraphs, and frequent sets of questions focus attention on the essential ideas. Sufficient material is included to provide a good beginning course.

G. W. W.

SAFETY, by Sidney J. Williams, *Director of Public Safety Division, Formerly Chief Engineer, National Safety Council,* and W. W. Charters, *Director of the Bureau of Educational Research, Ohio State University.* Cloth. Pages viii+451. 13.5×21.5 cm. 1940. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $1.60.

This textbook is suitable for either junior or senior high school classes. It provides subject matter for a complete practical course in safety education, and is so presented that coordination with the study of the basic sciences is insured. Safety devices, accidents, and hazards of the school and home are placed first and given major emphasis. Accidents peculiar to recreation and games, to the highway and other means of travel, and to numerous occupations are discussed. Throughout the authors have sought to promote formation of correct habits and regulation of both self and environment for prevention of accidents. Detailed instructions are given for conduct in cases of emergencies. Cooperation between individuals and various governmental agencies is stressed. Many teaching aids are provided.

G. W. W.

ELEMENTS OF ANALYTIC GEOMETRY, by Clyde E. Love, *Professor of Mathematics in the University of Michigan.* Second Edition. Cloth. Pages xii+159. 13×20.5 cm. 1940. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $1.75.

The present book has been prepared, not by revising the first edition, but by abridging the third (1938) edition of the author's longer book. Brevity was obtained by omitting bodily various topics considered less vital to the subject and not by skimping explanations or leaving out worked examples.

Chapter X, discussing rather thoroughly the graphs of rational algebraic functions, is new. This is followed by a chapter on polar coordinates. The section devoted to plane geometry concludes with a short chapter on parametric representation. The treatment of solid geometry has not been greatly changed. The drill exercises have been almost entirely worked over.

A number of theorems that might appear in the text of a longer book have been incorporated in the exercises. These may be developed at the discretion of the teacher.

JOSEPH J. URBANCEK,
Chicago Teachers College

COLLEGE ALGEBRA, by Charles H. Sisam, *Professor of Mathematics, Colorado College, Colorado Springs, Colorado.* Cloth. Pages xii+395. 13.5×21.5 cm. 1940. Henry Holt and Company, 257 Fourth Avenue, New York, N. Y. Price $1.90.

The earlier chapters are not merely routine reviews of elementary algebra but emphasize logical processes and basic concepts.

Due to the numerous graded exercises the instructor is given freedom of choice for assignments suited to the abilities of his students. Answers are given to the odd numbered exercises in the back of the book, and those for the even numbered exercises and problems will be printed separately.

The plan and preparation of the book is such that an instructor may vary the selection of the materials if he desires an order different from that given by the author.

Included are the usual topics of college algebra and the following Tables in the Appendix: Powers-Roots-Reciprocals, Natural Trigonometric Functions, Four-Place Logarithms, Compound Amount, Present Value, Amount of an Annuity, Present Value of an Annuity, and the American Experience Table of Mortality.

JOSEPH J. URBANCEK,
Chicago Teachers College

COLLEGE ALGEBRA, by Paul R. Rider, *Professor of Mathematics, Washington University, St. Louis, Missouri.* Cloth. Pages ix+372. 13.5×21.5 cm. 1940. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $2.00.

The first part of the book constitutes a thorough review of the topics of elementary and intermediate algebra. It is possible for well prepared classes to cover this part in a short time; but the book is so arranged that this part may be omitted without altering the continuity of the part that follows.

Some liberty in the choice of materials is provided. The individual chapters are largely independent providing for selection, if the instructor wishes a different order from that used in the book. Coherence of important ideas is accomplished by some repetition—sufficient to make necessary abridgments.

This book contains a liberal supply of selected and graded exercises. Answers to the odd numbered exercises are printed in the back of the book and answers to the even numbered exercises may be had in a small booklet, only upon the request of the instructor.

The author included an elementary chapter on finite differences which should appeal to forward looking instructors who see here some basic applications in the rapidly growing field of statistics.

JOSEPH J. URBANCEK,
Chicago Teachers College

VILLAGE OF PRE-CHRISTIAN ERA FOUND IN CANADA

Discovery of a prehistoric village in Canada, apparently inhabited by Indians centuries before the dawn of the Christian era, is reported by Dr. Emerson F. Greenman, archaeologist. Dr. Greenman has been leading a University of Michigan exploring expedition in the Georgian Bay region of Lake Huron.

Implements of quartzite revealed the presence of aboriginal settlement. Evidence of antiquity is the fact that what was then a beach is now high and dry, 297 feet above water. Before an accurate date of the village's life can be determined, the region must be studied by geologists, Dr. Greenman stated.

THE 1940 CONVENTION

All meetings to be held in the Hollenden Hotel, Cleveland, Ohio

GENERAL PROGRAM

Friday Morning, November 22, 1940
Ball Room

Convention Theme: "Science and the Citizen"

This program is intended to meet the interests of administrators and teachers of science and mathematics in the elementary schools, the junior and senior high schools, and the junior college.

9:30–10:00 *Reports of Committees*
National Science Committee—Harold H. Metcalf.
National Commission on Cooperative Curriculum Planning—John C. Mayfield.

10:00–10:40 "The Citizen and Research."
Dr. T. A. Boyd, Director of Laboratories Division, General Motors Corporation.

10:40–11:20 "The Mathematical Interpretation of History."
Dr. H. T. Davis, Professor of Mathematics, Northwestern University.

11:20–12:00 "The Way of a Bird in the Air" (illustrated with color movies).
Albert Dickson Simmons, Author of *Wing Shots—Camera Studies of Game Birds*, Nature Series Broadcaster over radio station WTAM. Contributor to conservation and nature publications.

Friday Evening, November 22, 1940, 6:00 P.M.

Annual Reception and Dinner

6:00–6:30 *Annual Reception*, Parlors B and C.
6:30–9:30 *Annual Dinner*, Ball Room.
Tickets $2.00, including tip.
Make reservations with James Gebhart, Euclid Shore High School, Euclid, Ohio.

Program: "Science, Mathematics, and Safety."
Sidney J. Williams, Director, Public Safety Division, Formerly Engineering Director, National Safety Council.

General Meeting

Saturday Morning, November 23, 1940

8:00–9:00 *Annual Business Meeting*, Parlor B.
9:00–10:00 *General Meeting*, Ball Room.
"Some Observations on the Physical Development of Adolescent Children."
Dr. William Walter Greulich, Professor of Physical Anthropology and Anatomy, and Director of the Brush Foundation, Western Reserve University Medical School, Cleveland, Ohio.
Dr. Greulich's program is pointed especially at the implications for education which have developed out of new knowledge on adolescent growth.

10:00–12:00 *Three Group Meetings.*

Elementary School Group.

Saturday Morning, November 23, 1940

Parlor A

Mary Melrose, presiding.
10:00–12:00 Round Table Discussion.

Questions to be discussed include:

1. What are the criteria for a good elementary science unit?
2. How can science be made functional in the lives of the pupils?
3. What are some of the most common subject matter errors made by elementary science teachers?
4. How can an elementary science program be started in different types of school systems?

Chairman—Dr. G. P. Cahoon, College of Education, Ohio State University, Columbus, Ohio.
Dr. Paul E. Kambly, Head, Science Department, University Experimental School, Iowa State University, Iowa City, Iowa.
Mr. H. M. Buckley, Assistant Superintendent, Cleveland Public Schools.
Mrs. Margaret L. Wilt, Board of Education, Chicago, Illinois.
Dr. David W. Russell, National College of Education, Evanston, Illinois.
Mr. W. L. Shuman, Assistant Superintendent, Cuyahoga County Schools, Cleveland, Ohio.
Miss Anna E. Burgess, Principal, Doan School, Cleveland, Ohio.
Dr. W. C. Croxton, State Teachers College, St. Cloud, Minnesota.

Junior High School Group.

Saturday Morning, November 23, 1940

Cypress Room

Ellis C. Persing, presiding.
10:00–10:40 "The Crucial Place of Junior High School Mathematics in Education for Competency."
Dr. H. C. Christofferson, Professor of Education, Miami University, Oxford, Ohio.
10:40–11:20 "Experimental Science for the Citizen."
Dr. Earl R. Glenn, Head of the Science Department, New Jersey State Teachers College at Montclair.
11:30–12:00 "Introducing Telescope Making to the Schools."
James L. Russell, Amateur Astronomer and Director of the "Star Gazer's Club" broadcasts.

Senior High School—Junior College Group.

Saturday Morning, November 23, 1940

Ball Room

Dr. J. S. Georges, presiding.
10:00–10:40 "Science Education in Consumer Buying."
Dr. George L. Bush, Head of the Science Department, East High School, Cleveland, Ohio.
10:40–11:20 "The Consumer Looks at Textiles."
(A classroom dramatization adapted from the work of Mr. C. A. Henderson's Cleveland Curriculum Center Groups in Applied Science.)
11:20–12:00 *Studio Trip*, National Broadcasting Company.

All sectional meetings are at 2:00 P.M., Friday November 22, 1940

Section Meetings

Biology

Joint meeting with the Greater Cleveland Biology Society

Parlor A

SECTION PROGRAM

2:00 "Park Areas as Teaching Assets in Biology."
Dr. Arthur B. Williams, Curator of Education Cleveland Museum of Natural History, Cleveland, Ohio.
2:50 "Freshwater Life in Biology Instruction."
Dr. J. Paul Visscher, Head, Biology Department, Western Reserve University.
3:40 "Some Cleveland Classroom Procedures."
Members of the Greater Cleveland Biology Society tell about their favorite teaching methods, and lead an informal discussion.
Nell C. Henry, Glenville High School, Leader.
Ellis C. Persing, West Technical High School.
"The Cleveland Natural Science Club"
Eugenia Couden, James Ford Rhodes High School.
"Modern Technics in First Aid."
E. D. Collings, John Marshall High School.
"The Use of the Rotary System in Teaching Biology."

Chemistry

Joint Meeting with North Eastern Ohio Chemistry Teachers Association

Room 544—5th floor

SECTION PROGRAM

2:00 "The Motor Car's Debt to Science."
Dr. T. A. Boyd, Director of Laboratories Division, General Motors Corporation.
2:50 ROUND TABLE DISCUSSION
"Development of General vs. Special Science Courses in Secondary Schools."
Vernon C. Culp, Leader, West High School, Akron, Ohio.
"The Consumer Science Point of View."
R. A. McCormick, Wellington High School, Wellington, Ohio.
"The Combined Introductory Course in Secondary Science."
H. W. Baker, Rhodes High School, Cleveland, Ohio.
"The Pure Science Point of View."
R. J. Holder, Lorain High School, Lorain, Ohio.

Elementary Science

Ball Room

SECTION PROGRAM

The program will be devoted to descriptions of science units which have been successfully carried out by the speakers.
2:00–2:30 "Science Helps Progress."
Eleanor V. Liddle, Sheridan School, Youngstown, Ohio.
2:30–3:00 "Music-Makers in Science Time."
Mildred Pelikan, Memphis School, Cleveland, Ohio.
3:00–3:30 "Community Resources and Elementary Science."
Earl Studt, Supervisor of Elementary Science, Lincoln Training School, Ypsilanti, Michigan.
3:30–4:00 "Planned Field Trips—An Integral Part of Science Units."
Dora Wood, Hayes School, Lakewood, Ohio.

General Science

Parlor C

SECTION PROGRAM

2:00–2:40 "Teaching Patterns in General Science."
Dr. W. L. Beauchamp, Department of Education, Chicago University
2:40–3:20 "Introduction of Recent Developments in Meteorology into General Science Courses."
Mr. B. C. Haynes, Associate Meteorologist, United States Weather Bureau, Washington, D. C.
3:20–4:00 "The Use of Intra-Venous Medication as a Treatment of Disease."
Dr. Amos T. Fisher, Physician and Surgeon, Lakewood, Ohio.

Geography

Rendezvous Room

12:15 *Luncheon* ($1.00 per plate).
(Send reservations to A. O. Baker, John Marshall High School, Cleveland, Ohio.)

SECTION PROGRAM

1:00 "Man—Maker of Deserts."
Herbert W. Brandt, Director, Cleveland Bird Research Foundation; Author of "Texas Bird Adventures"; Owner of one of America's largest private ornithological collections.
1:40 "The Twins—Observe and Conserve."
Albert Dickson Simmons, Author of *Wing Shots*, Contributor to *Nature, Field and Stream, Bird Lore*, and *National Sportsman* magazines. Nature Series broadcaster over station WTAM.
2:40 Business Meeting of Association Members who are also members of the Geography Section.

Mathematics

Cypress Room

SECTION PROGRAM

2:00 "Greetings from the National Council of Mathematics Teachers."
President Mary A. Potter, Racine, Wisconsin.
2:25 "Mathematics and the Social Sciences."
Professor H. T. Davis, Northwestern University, Evanston, Illinois.
2:50 "Mathematics and the Consumer."
Dr. John A. Ramseyer, University School, Ohio State University.
3:15 Panel Discussion "Mathematics and the Citizen."
Leader: Dr. Joel S. Georges, Wright Junior College, Chicago, Ill.
Professor Leroy H. Schnell, State Teachers College, Indiana, Pa.
Lewis A. Taylor, North Shore Country Day School, Wilmette, Ill.
Dr. O. E. Overn, Du Sable High School, River Forest, Ill.
A. E. Downer, Cass Technical High School, Detroit, Michigan.

Physics

Room 444 (fourth floor)

SECTION PROGRAM

2:00 "Rescuing Physics from the Textbooks."

Dr. R. M. Sutton, Professor of Physics, Haverford College, President of the American Association of Physics Teachers.

2:30 "The New Physics."
Professor Robert S. Shankland, Head of Physics Department, Case School of Applied Science.

3:00 "High School Physics for General Education."
Report of the Committee on Physics Teaching
Kenneth E. Vordenberg, Washington High School, Cincinnati.

3:30 ROUND TABLE DISCUSSION.
Ellsworth Obourn, Leader, John Burroughs School, Clayton, Mo.

PROGRAM BY EXHIBITORS

All Demonstrations and Lectures on Friday November 22, 1940

GENERAL

Title: *Editors as Goats*
Speaker: Dr. Hanor A. Webb
Time: 12:00–12:30
Place: Ball Room
Sponsor: American Education Press, Inc.

BIOLOGY

Title: *The Preparation of Corrosion Specimens*
Speaker: Alfred Medendorp
Time: 4:00–4:30
Place: Parlor A
Sponsor: Denoyer-Geppert Company

CHEMISTRY

Title: *Beryllium and its Alloys*
Speaker: L. G. Yoder
Time: 4:00–4:30
Place: Room 544
Sponsor: Lafayette Instruments, Inc.

ELEMENTARY SCIENCE

Title: *Elementary Science Apparatus*
Speaker: D. L. Barr
Time: 4:00–4:30
Place: Ball Room
Sponsor: W. M. Welch Company

GENERAL SCIENCE

Title: *Applications of the 16 mm. Sound Projector in the Science Classroom*
This demonstration includes the showing of a new film "How Motion Pictures Move and Talk"
Speaker: Carl Shreyer
Time: 4:00–4:30
Place: Parlor C
Sponsor: Bell & Howell Company

MATHEMATICS

Title: *The Slide Rule and the Army*
Speaker: Dr. Charles A. Stone, Graduate School, De Paul University, Chicago, Illinois